# 320
# DUAL CHANNEL
# DC AMPLIFIER
# RECORDER

# OPERATING AND SERVICE MANUAL

HEWLETT PACKARD hp SANBORN DIVISION

IM-320-2

HEWLETT PACKARD hp SANBORN DIVISION

## CERTIFICATION

*The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.*

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HEWLETT PACKARD SANBORN DIVISION

OPERATING AND SERVICE MANUAL

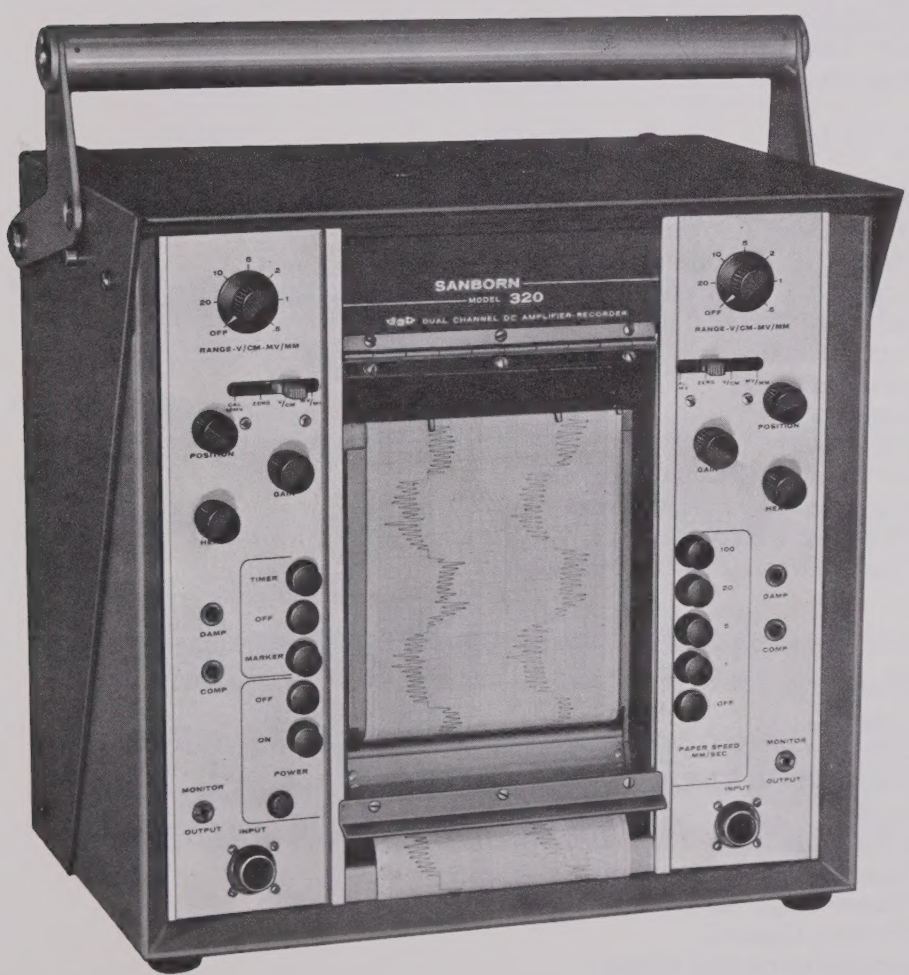
# 320
# DUAL CHANNEL
# DC AMPLIFIER
# RECORDER

Printed in U.S.A.

# INSTRUCTION MANUAL

# DUAL CHANNEL DC AMPLIFIER RECORDER

## MODEL 320




## SANBORN COMPANY

## WALTHAM 54, MASSACHUSETTS

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SANBORN DIVISION

# MANUAL CHANGES

MODEL 320, 320R, 320T, 320TR
320TX, 320X, 320XR

Dual Channel Recorder
(MANUAL TITLE)

MANUAL PREFIXED: IM-320-2

MAKE ALL CHANGES IN THIS MANUAL ACCORDING TO THE ERRATA BELOW. ALSO CHECK THE FOLLOWING TABLE FOR YOUR INSTRUMENT CR/PCO NUMBER AND MAKE ANY LISTED CHANGE(S) IN THE MANUAL.

| CR/PCO NUMBER | MAKE MANUAL CHANGES | CR/PCO NUMBER | MAKE MANUAL CHANGES |
|---|---|---|---|
| ALL | ERRATA | CR14017 | CHANGE 4 |
| CR11435 | CHANGE 1 | CR14281 | CHANGE 5 |
| ALL | CHANGE 2 | CR14320 | CHANGE 6 |
| CR11908 | CHANGE 3 | CR14378 | CHANGE 7 |

Δ NEW OR REVISED ITEM

ERRATA:

Page 2, Paragraph 2,
Under SENSITIVITY change smooth gain control data to read "a smooth gain control permits adjustment of range from 2-1/2 to 1."

Page 3, Paragraph 2,
Under CALIBRATION change "10 millivolts ±1%" to read "10 millivolts ±2%".

Add the following identification data to the blank side of the page following page 4:

UNIT IDENTIFICATION:

Model 320R is a rack-mounted Model 320 Recorder.
Model 320T, 320TR is a medical version of the Model 320 with paper speeds of 2.5, 5, 25, and 50 mm/sec. Model 320TR is a rack-mounted Model 320T.
Model 320X, 320TX, 320XR have been designed to operate from 50 cycle, 115V or 230V source. A switch located at the rear of the unit provides the means of selecting the desired voltage. The X indicates that the recorder is an export version of the standard model.

May 12, 1966
DATE

EIM-320-2A
SUPPLEMENT NUMBER

ERRATA: (Cont.)

Rack-mounted versions are made up of the following unit and kit:

| AMT. | DESCRIPTION | 320R | 320TR | 320XR |
|---|---|---|---|---|
| 1 | Rack-mount Kit | 462-231 | 462-231 | 462-231 |
| 1 | as ordered Paper Take-Up | 320R-300 | 320R-300 | 320R-300 |
| 1 | Portable 2-Channel Recorder | 320R | 320T | 320X |
| Delete: | | | | |
| 1 | Carrying Case | 320-1400 | 320-1400 | 320-1400 |
| 1 | Fuse Bracket | 322-107P1 | 322-107P1 | 322-107P3 |
| 1 | Side Plate Spacer | 320-161 | 320-161 | 320-161 |
| 1 | Side Plate Spacer | 320-162 | 320-162 | 320-162 |
| 1 | 60-cycle Nameplate | 320-182 | 320T-104 | ------- |
| 1 | as ordered 50-cycle Nameplate | 320-183 | 320T-105 | 320X-183 |
| 1 | Cord and plug set | 10G3-33MW | 10G3-33MW | 10G3-33MW |
| Add: | | | | |
| 1 | 60-cycle Nameplate | 320R-102 | 320TR-102 | -------- |
| 1 | as ordered 50-cycle Nameplate | 320R-103 | 320TR-103 | -------- |
| 1 | 50-cycle Nameplate | --------- | --------- | 320XR-103 |

Page 9, Paragraph 5, under HEAT;
add the following: Maximum stylus heat control settings should be used when recording frequencies in the middle to high frequency range of the recorder frequency response characteristics.

CHANGE 1:

Page 13, Add Paragraph,

10. REMOTE MARKER

Connector J5, at the rear of the recorder, can be used to apply an external marker signal to the Marker.

a. Construct a signal cable with the phone plug supplied

b. Connect the cable to J5.

c. Excite the marker writing arm from any source (e.g., SPST switch) which provides a contact closure.

| CR/PCO Number | Make Manual Changes |
|---|---|
| CR14666 | CHANGE 8 |
| CR14776 | CHANGE 9 |
| CR14811 | CHANGE 10 |
| CR14928 | CHANGE 11 |

| CR/PCO Number | Make Manual Changes |
|---|---|
| CR14951 | CHANGE 12 |
| PCO17-15076 | CHANGE 13 |
| PCO17-15263 | CHANGE 14 |
| | |

Δ NEW OR REVISED ITEM

CHANGE 2: Page 1, Paragraph 1,
Add following to GENERAL DESCRIPTION,
Sanborn Dual Channel DC Amplifier-Recorder, Model 320 and 320T, use a printed circuit plug-in regulator board. The three models are identified as follows:

Model 320-100-C12, 1200 cycle oscillator,
Model 320-100-C24, 1200 cycle oscillator,
Model 321-100-C10, 2400 cycle oscillator.

CHANGE 3: Page 4, Paragraph 3,
Under INPUT, change "12-terminal connector, etc" to read "3-contact (2 contacts guarded) male connector, etc."

Page 10, Paragraph 6
Under SIGNAL CONNECTION, delete Figure 10 and reference thereto. Change the letter designations to coincide with the 3-contact connector as follows:

Terminal E to A
Terminal F to B
Terminal M to C (ground)
Terminals K, A, B, C, D, H, J, L, N to guard.

CHANGE 4: Change Parts List at the rear of the manual;
Timer Assembly No. 152-1300B-C2P5 is changed to REED TIMER ASSEMBLY No. 14002C. The timers are interchangeable. The Model 14002C is for 1-second, 60-cycle, applications and consists of the following:

| | | |
|---|---|---|
| Switch Actuator Assembly | | 14002-60010 |
| Arm | 14002-00010 | |
| Hub | 14002-20010 | |
| Rivet | 47A-1 | |
| Magnet | 62RC-2 | |
| Set Screw | 81A-632G | |
| Timer Mounting Bracket | | 154B-1305P1 |
| Printed Board | | 752-417 |
| Sync. Motor (60 rpm, 60 cy) | | 38B-21 |
| Magnetic Reed Switch | | 62V-1 |
| Sems | | 83A-6-4B |

Timer Assembly No. 152-1300B-C2P6 is changed to Reed Timer Assembly No. 14002D. The parts are the same as for the 14002C except as follows:

Sync Motor (60 rpm, 50 cycle) 38B-21A

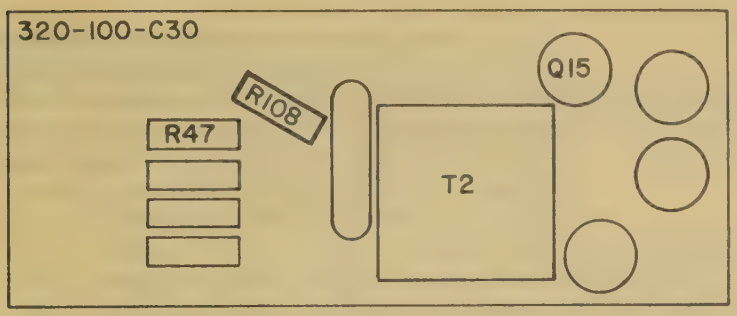
CHANGE 5: Change Schematic and Replacement Parts List at the rear of the Manual;
Change R108 to 100K ±5%, 1/2W, Sanborn No. 50AB-104J, Vendor Code EB(AB).
Add NOTE 9. Resistor R108 is added in parallel with R48 to provide 2% calibration accuracy.

CHANGE 6: Change Schematic and Replacement Parts List at the rear of the Manual;
Change C25 to 120μF, 10V, Sanborn No. 8T-8, Vendor Code 150D (SPR).

CHANGE 7: Change Schematic and Replacement Parts List;
Change R70 and R80 to 3.3K ±5%, 1/2W, Sanborn No. 50AB-332J, Vendor Code EB (AB).

CHANGE 8: Change Schematic and Parts List;
C46; change to .02μF; Sanborn No. 8E-17, Vendor ID-203 Centralab
C46 is to be located between the base and collector of Q21.

CHANGE 9: Change Parts List;
Printed circuit assembly 320-100-C30 is revised to show the location of R108. See figure.




CHANGE 10: Change Schematic and Parts List;

Q1; change to 2N1307 selected; Sanborn No. 16T-58B; Vendor SAN.
Q7; change to 2N1307; Sanborn No. 16T-58; Vendor 2N1307 (RCA).
Q3, Q10, Q11, Q12; change to 2N3393; Sanborn No. 16T-78; Vendor 2N3393 (GE).
C51; capacitor is deleted.

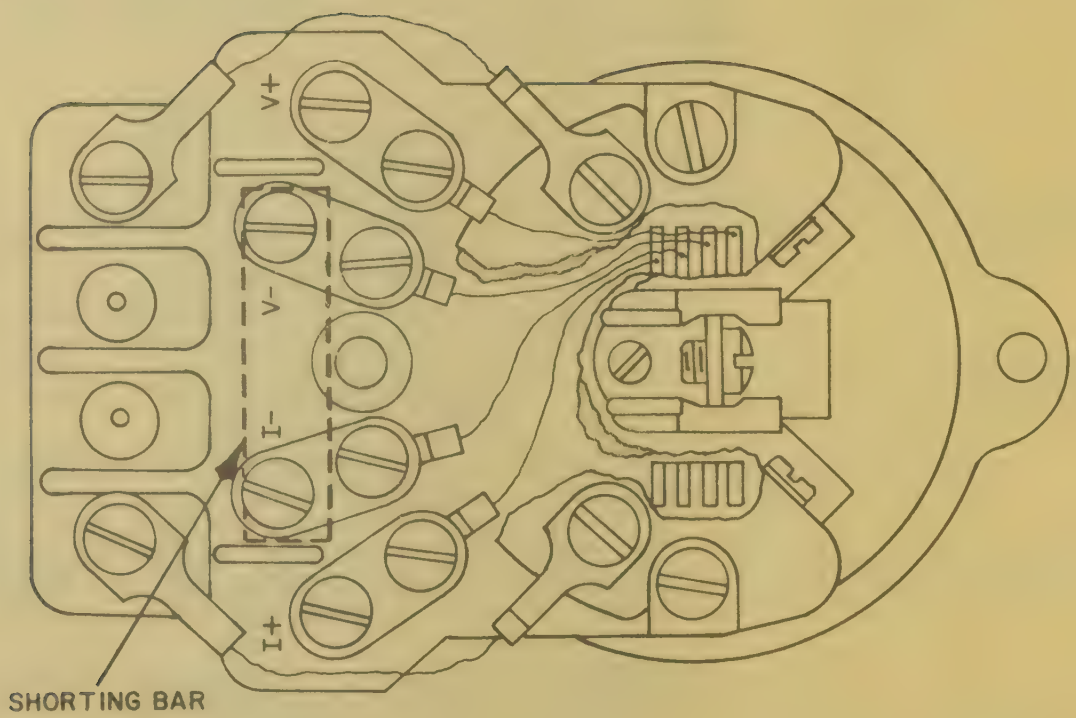
Page 34, Paragraph 14 and Figure 11 in the Parts List;
Add the following information;
CHANGES TO GALVANOMETER INSERT

1. Galvanometers Models 607, 608, 608D formerly used Galvanometer INSERT Model 606. They will now use Galvanometer INSERT Model 606B as a direct replacement.
2. When Galvanometer INSERT model 606B is installed the GALVANOMETER Model number will change as follows:
   607 will become 607B
   608 will become 608B
   608D will become 608E
3. Electrically Galvanometer INSERT 606 and 606B are the same.
4. Physically INSERT 606 has two coils on the coil frame. One lead of each coil is connected together at the coil frame. Three leads are brought up to the three terminals at the top of the coil frame. These terminals are then connected to the +, CT, -, terminals on the cap. The fourth terminal on the cap is not used.
5. INSERT 606B coils are not connected at the coil frame. Four leads are brought up to the four terminals at the top of the coil frame. These terminals are then connected to I+, I-, V-, V+ terminals on the cap. A shorting bar is placed from I- to V- thus making it electrically the same as the Model 606.
6. The Model 606B without the shorting bar becomes Galvanometer INSERT Model 606A. The 606A will be used in latest Sanborn Recorders of the 350 Series. The required shorting of terminals I-, V- will take place in the Driver Amplifier.

   NOTE: INSERT 606A (without shorting bar) cannot be used in a system using 606 or 606B INSERTS.

CHANGE 10: (Cont.)

7. For a short time the old style CAP with four terminals marked +, CT, -, (one unused) will be placed in service. The four ends of the two coils will be brought up to the four terminals at the top of the coil frame and then connected to the +, CT, -, (unmarked) terminals. A shorting bar will be across CT and -. This will then be a 606B INSERT.



CHANGE 11: Change Schematic and Parts List;
C45; capacitor deleted.
R109 resistor, 10Ω, ±5%, 1/2W; Sanborn No. 50AB-100J; Vendor EB(AB).
R109 added between J5-TIP (Remote Marker) and the open side of S5 on the timer assembly.

CHANGE 12: Change Schematic and Parts List;
R74; Change to 120K, ±5%; Sanborn No. 50AB-124J; Vendor EB(AB).
R88;; change to 10K, ±5%; Sanborn No. 50AB-103J; Vendor EB(AB).
C30; change to 1μF, 35V; Sanborn No. 8T-37; Vendor 150D155X9035B2 (SPR).

CHANGE 13: Change Schematic and Parts List;
Q22; change 2N2552; Sanborn No. 16T-38; Vendor 2N2552 (TEX).

CHANGE 14: Change Schematic and Parts List;
R89; change to 33Ω, ±5%, 1W; Sanborn No. 51D-330J; Vendor GB(AB).

HEWLETT-PACKARD/SANBORN DIVISION
175 WYMAN STREET
WALTHAM, MASS. 02154
AREA CODE 617
TEL: 894-6300
MAY 18, 1965

INSTRUCTION MANUAL
SANBORN RECORDERS
THERMAL (HEATED STYLUS)

IM-150-350-1

OPERATING NOTE:

Maximum stylus heat control settings should be used when recording frequencies in the middle to high frequency range of the recorder frequency response characteristics.

# SECTION 1
# DESCRIPTION

## 1. GENERAL DESCRIPTION

The Sanborn Dual Channel DC Amplifier Recorder Model 320 is a portable, two-channel recording system, designed for general purpose d-c recordings. Each channel is a stable, high-gain carrier amplifier which incorporates the dependability of transistor electronics with easily serviced printed-wiring plug-in boards. The input circuits are isolated from ground and include a guard shield, providing accurate recording in the presence of high common-mode voltages, with complete inter-channel isolation.

The system is contained in a heavy-duty carrying case with combination carrying handle and adjustable stand This feature permits positioning the instrument for recording either vertically, horizontally, or at an angle of 20 degrees

Inkless recordings are made by hot-wire writing arms on heat-sensitive Sanborn Permapaper chart, for fast accurate recording on true rectilinear coordinates. Approximately six inches of Permapaper chart is visible at all times for viewing the record as it is being made. Notes may be written directly on the Permapaper, using pencil, pen, or ballpoint pen. The four-speed chart drive is controlled by front panel push-buttons, and provides a wide range of recording speeds from 1 millimeter per second to 100 millimeters per second. A marker arm in the right margin of the chart, with an internal one-second timer, provides both coding and time indications for precise identification of recorded data. In addition to the output indicated by the recording galvanometers, an auxiliary front panel output jack is available for each channel and may be used to monitor the recording with an external indicating device such as an oscilloscope.

## 2. PERFORMANCE DATA

| | |
|---|---|
| Channels: | Two-channel recording, each channel 5.0 centimeters wide. |
| Dimensions: | Approximately 13-3/4" long, 14" wide, and 9-3/4" deep. |
| Weight: | 55 pounds. |
| Power Requirements: | 103 to 127 volts, 60 cycles, single-phase, approximately 100 watts. |
| Recording Speeds: | 1, 5, 20, and 100 millimeters/second. |
| Sensitivity: | 0.5, 1, 2, 5, 10 and 20 millivolts/millimeter and volts/centimeter, corresponding to 25, 50, 100, 250, 500 millivolts, 1, 2.5, 5, 10, 25, 50 and 100 volts edge to edge of the 50 millimeter recording chart. A smooth gain control permits adjustment between 50% and 125% of calibration sensitivity. |
| Input Impedance: | 0.5 megohm on millivolt ranges, 1.0 megohm on volt ranges, floating and guarded with inter-channel isolation. Source resistance should be below 10,000 ohms on millivolt ranges only. |
| Frequency Response: | DC to 125 cycles within 3 db at 10 millimeters peak-to-peak amplitude.<br>DC to 50 cycles within 3 db at 50 millimeters peak-to-peak amplitude. |
| Response Time: | 5 milliseconds maximum from 10% to 90% of final deflection; overshoot 4% or less. |
| Noise: | 0.25 millimeter peak-to-peak maximum at calibrated gain. |
| Common Mode Voltage Tolerance: | ±500 volts maximum. |

## 2. PERFORMANCE DATA (Continued)

| | |
|---|---|
| Common Mode Rejection: | 140 db minimum at d-c;<br>120 db minimum at 60 cycles with no input unbalance;<br>100 db minimum at 60 cycles with 5000 ohms unbalance. |
| Drift: | 0.25 millimeter maximum as a function of 10°C ambient temperature change in the range of 0°C to 40°C; 0.1 millimeter maximum as a function of line voltage variation from 103 to 127 volts. |
| Gain Stability: | Better than 1% with ambient temperatures from 0°C to 40°C; better than 1% with line voltage changes from 103 to 127 volts. |
| Limiting: | Electrical, approximately 115% of full scale. |
| Calibration: | 10 millivolts ±1% , internal. |
| Monitor Output: | Approximately 40 millivolts/millimeter deflection across at least 0.1 megohm load. |
| Linearity: | Maximum non-linearity 0.25 millimeter. * |

*Sanborn Company measures and defines linearity as follows:

a. Adjust zero-signal stylus position to mid-chart. Then apply DC signal for a 20-division up-scale stylus deflection. Measure amplitude of this DC signal carefully, in terms of input signal voltage.

b. Now apply, in order, 0%, 25%, 50%, 75%, 100%, and 125% of the DC signal applied in step a.

c. Now apply the same series of signals, with opposite polarity.

d. Look for stylus deflections which almost exactly coincide with the heavy lines every five divisions on the chart. Deflections should coincide exactly at mid-scale and at +20 divisions. Linearity error is the distance on the chart by which each actual deflection misses its heavy line.

Note: to avoid hysteresis effects, perform test at a high paper drive speed.

## 3. FRONT PANEL DATA (EACH CHANNEL)

| | |
|---|---|
| RANGE V/CM-MV/MM: | Multi-position rotary switch to attenuate the signal by fixed factors. |
| POSITION: | Control for adjusting the position of the writing arm on the recording chart. |
| CAL-ZERO-V/CM-MV/MM: | Four-position function switch which determines the operating mode of the amplifier. |
| GAIN: | Control for setting the gain of the amplifier so that the sensitivity values stated on the RANGE switch are accurate, and for providing intermediate sensitivities. |
| HEAT: | Control for adjusting the heat of the writing arm stylus for adequate trace density. |
| DAMPING: | Screwdriver-adjusted control for setting the damping of the galvanometer. |
| COMPENSATION: | Screwdriver-adjusted control for compensating for the loss in galvanometer response at high frequencies. |
| MONITOR OUTPUT: | Miniature jack to provide output signals for monitoring devices. |
| INPUT: | 12-terminal connector to which the input signals are applied. |
| Controls common to both channels: | |
| POWER-TIMER-MARKER: | Series of five push-button switches at the left side of the panel for applying power, starting the one-second timing motor, or marking the recording. |
| PAPER SPEED: | Series of five push-button switches at the right side of the panel for selecting the recording speed. |
| INDICATOR: | Lights when power is applied. |

## OPERATING CONTROLS

### RANGE

SET TO OBTAIN DESIRED WRITING ARM DEFLECTION EXPRESSED IN VOLTS PER CENTIMETER OR MILLIVOLTS PER MILLIMETER.

### CAL-ZERO-V/CM-MV/MM

SET TO CAL TO INSERT CALIBRATION SIGNAL AND ADJUST SENSITIVITY WITH GAIN CONTROL; SET TO ZERO TO MAKE NO-SIGNAL POSITION ADJUSTMENT; SET TO V/CM OR MV/MM TO SELECT BASIC SENSITIVITY.

### POSITION

SET THE ZERO INPUT SIGNAL POSITION OF WRITING ARM.

### GAIN

ADJUST TO CALIBRATED OR INTERMEDIATE SENSITIVITY.

### TIMER - MARKER

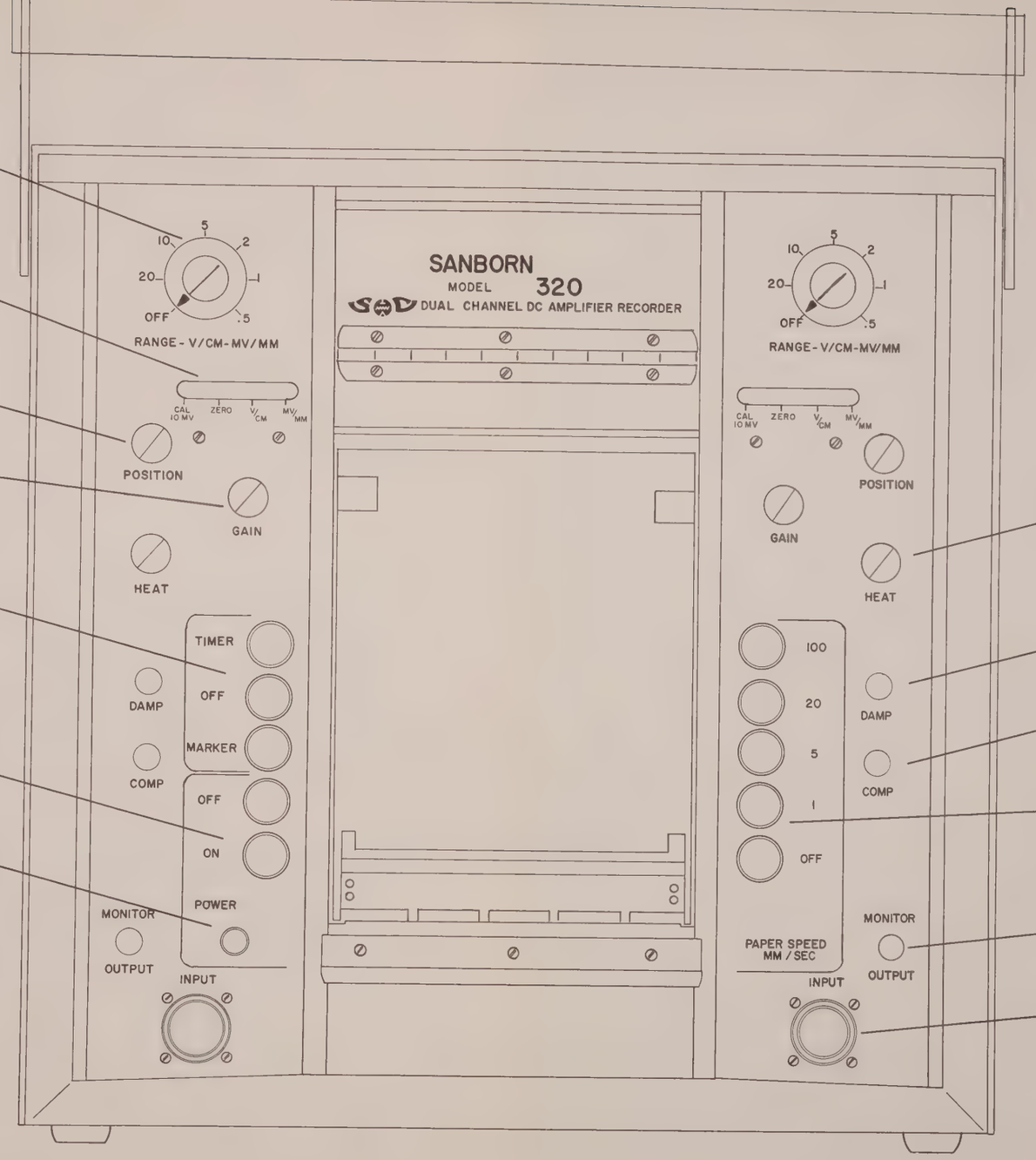
PRESS DOWN TIMER FOR ONE-SECOND TIMING MARKS. PRESS DOWN AND HOLD MARKER TO MARK RECORD FOR IDENTIFICATION. PRESS DOWN BOTH BUTTONS FOR SIMULTANEOUS TIMING AND MARKING.

### POWER

PRESS DOWN ON TO TURN ON RECORDER.

### INDICATOR

LIGHTS WHEN POWER IS APPLIED.




### HEAT

ADJUST FOR GOOD TRACE DEFINITION.

### DAMPING

ADJUST FOR BEST GALVANOMETER DAMPING.

### COMPENSATION

ADJUST FOR BEST GALVANOMETER RESPONSE.

### PAPER SPEED

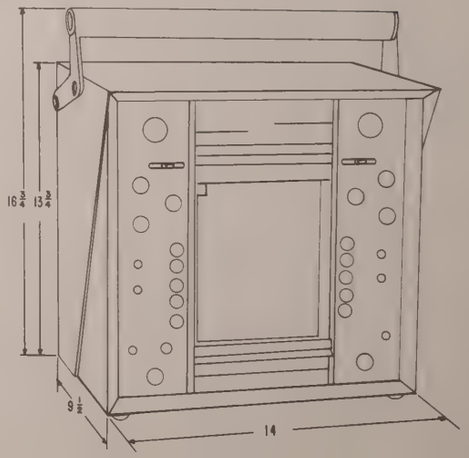
PRESS DOWN APPROPRIATE BUTTON TO SELECT RECORDING SPEED.

### MONITOR OUTPUT

CONNECT EXTERNAL MONITORING DEVICE.

### INPUT

CONNECT INPUT SIGNAL.




SANBORN DUAL CHANNEL DC AMPLIFIER - RECORDER MODEL 320

# SECTION 2
# INSTALLATION AND OPERATION

## 1. UNPACKING

Remove the recorder from its packing case and place on a table, bench top, or other firm, flat support. Open the accessory package and check the contents against those shown in the Replacement Parts List at the rear of this manual. Included in this package are spare writing arms, special tools, connectors, etc. These items will be used in the operation and maintenance of this instrument.

## 2. POWER CONNECTION

Most recorders of this model operate at 115 volts, 60 cycles, which is standard through most of the United States. Check the nameplate at the rear of the recorder before connecting to a power outlet; be sure that the line voltage and frequency are the same as that stamped on the nameplate. Contact the local power company if there is any doubt. (Special recorders are designed for 220/250 volts, 50 or 60 cycles; use these with the corresponding electric power. Do not use any recorder on d-c or 25 cycle a-c power lines.) Before connecting the recorder to the power line, press down on the push-button POWER OFF switch.

The power cord is stored in the carrying handle when not in use. Remove it and note the three-terminal plug at the end of the cord. This plug may be used directly on power outlets where a three-wire system is used. If the power system is of the two-wire type, use the three-wire adapter plug (accessory) between the power cord plug and the power outlet. Connect the short green lead of the adapter to a suitable ground.

### 3. OPERATING POSITION

The recorder may be used in a vertical or horizontal position, or at an angle of 20 degrees, with no effect on the operation of the instrument.

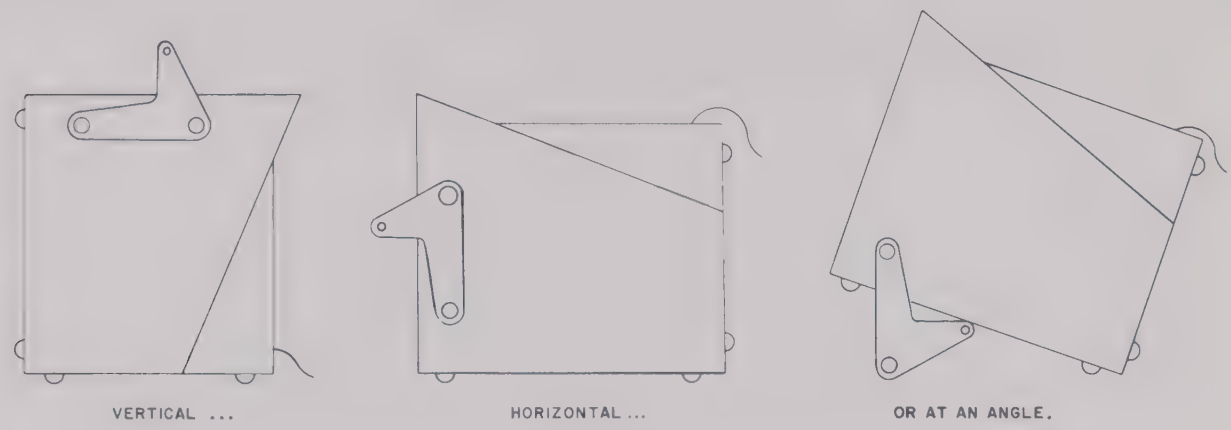



Figure 1

The latter position is ideally suited for bench or table top use, if the operator is seated. The recorder may be placed in this position by releasing the catch at each side of the carrying handle, then rotating the handle backwards, so that it supports the back of the case.

### 4. CHART LOADING

Sanborn Permapaper chart used in this recorder is supplied in 200 foot rolls. Charts printed with green coordinates are usually used in industrial applications (Sanborn part number 651-52); charts printed with black coordinates are usually used in medical applications (Sanborn part number 651-42). Special Translucent Permapaper is available and is suitable where Ozalid reproduction of the recording is desired (Sanborn part number 651-182). Each roll of Permapaper is marked with a star, 30 feet from the end of the roll, and serves as a warning to the operator that the paper supply is nearing exhaustion. Permapaper is installed in the recorder by following the illustrations in Figures 2 through 9 on the following pages.

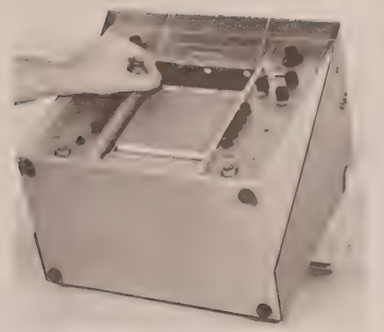


Figure 2. Turn the instrument off. Rotate the carrying handle beneath the case so that the recorder rests at a 20 degree angle. Lift the plastic viewing window up and push the writing table lock lever toward the galvanometers, releasing the table and lifting the writing arms from the writing edge.

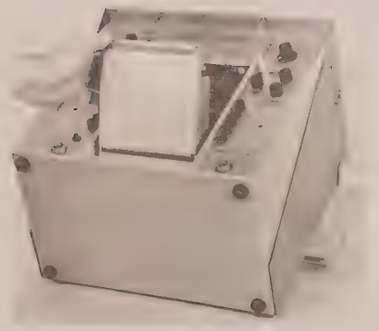


Figure 3. Lift the paper table up and toward the operator. If the paper supply is not completely exhausted, roll the remaining paper back on to the roll. Lift the paper roll out of its brackets and away from the paper drive compartment.

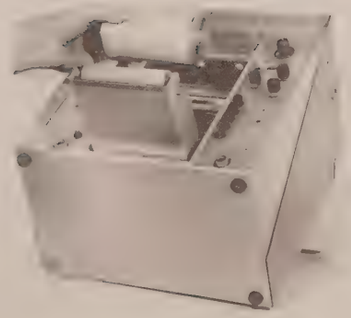


Figure 4. Remove the spool by pulling the left hand end disc out of the paper roll, then pull the paper roll core off the spindle. Place the new roll over the spindle. When installed, paper should leave the roll so that the grid lines of the chart are visible when pulled over the writing edge. Press the left end disc into the paper roll. Place the loaded spool in its mounting bracket, removable end disc to the left.

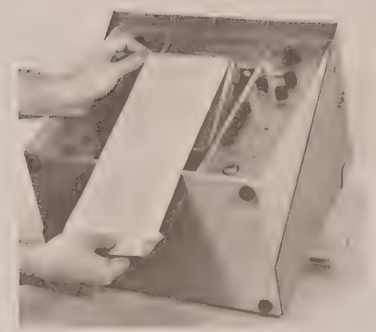


Figure 5. Pull the leading edge of the paper over the rubber brake roll and the writing edge. Now, lower the paper table into place, keeping the paper as taut as possible over the writing edge to keep from entangling the writing arms. Pull the lock lever back toward the operator.

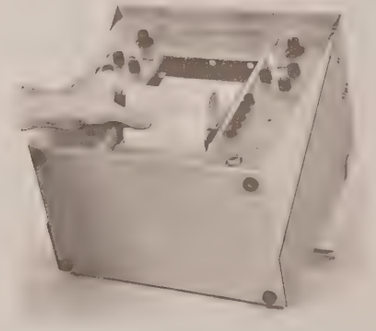


Figure 6. Fold the leading edge of the paper. Set the paper speed to 20 mm/second and start the motor. Feed the end of the paper down in between the drive roll guard plate and the end of the table. The drive roll will pick up the paper and carry it through, appearing at the other side of the guard plate and between the plate and the metal idler roller.

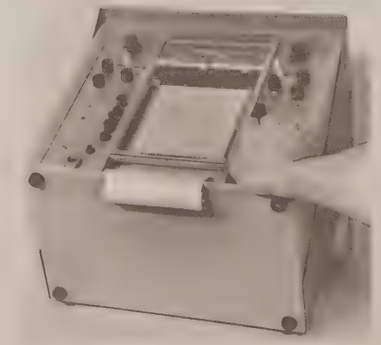
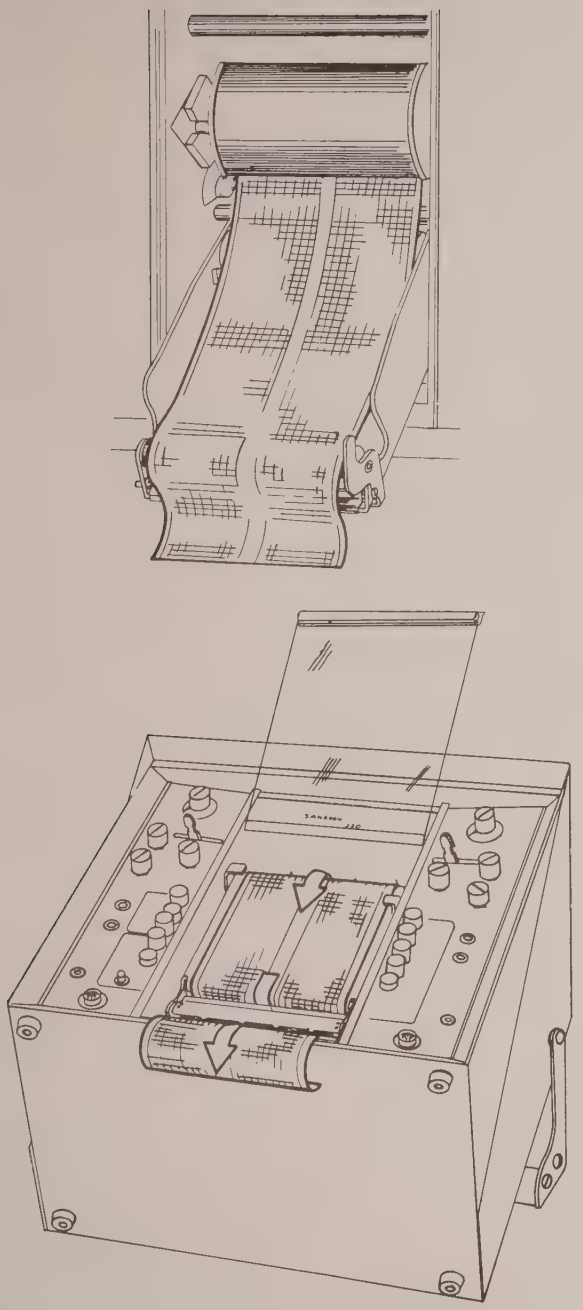


Figure 7. When the paper feeds satisfactorily, shut the drive motor off and lower the viewing window into place.

## PAPER LOADING IN SANBORN "320" SERIES OF RECORDING INSTRUMENTS



Paper Travel in Sanborn "320" Series of Recording Instruments.

4. CHART LOADING (Continued)

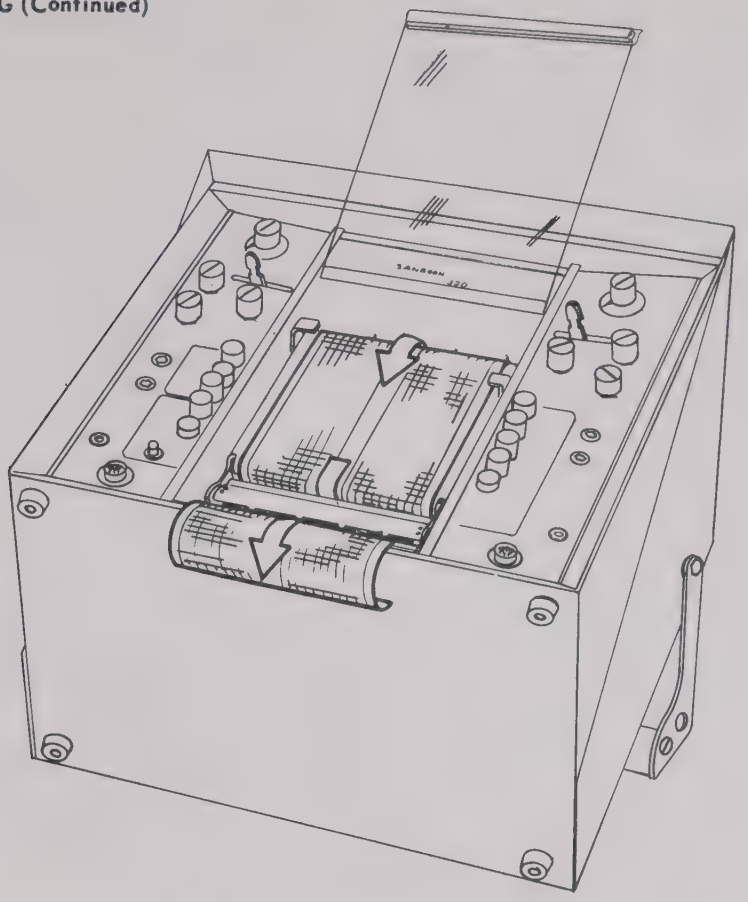


Figure 8

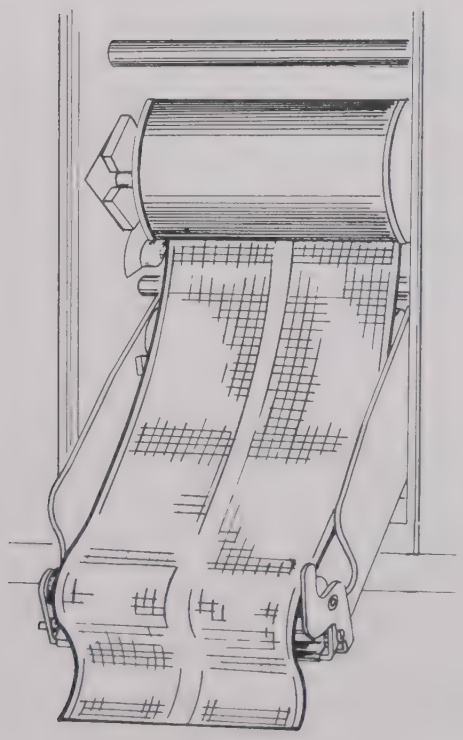
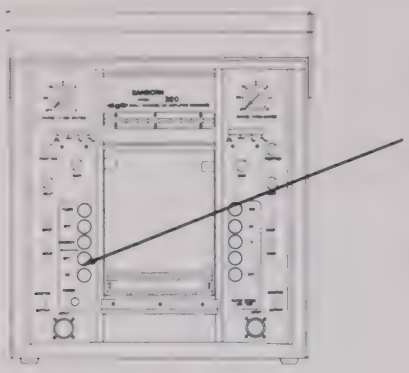


Figure 9

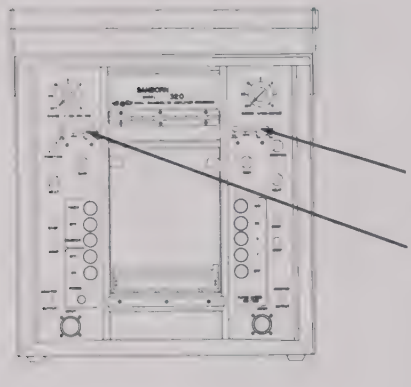
## 5. OPERATIONAL CHECK

The following tables present the most frequently used controls in the logical order of their use.



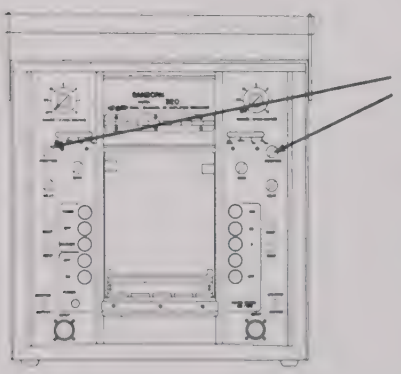
POWER ON-OFF:

Press the push-button POWER "ON" switch; the red indicator should light. Allow approximately five seconds for the amplifiers to stabilize before making other adjustments.



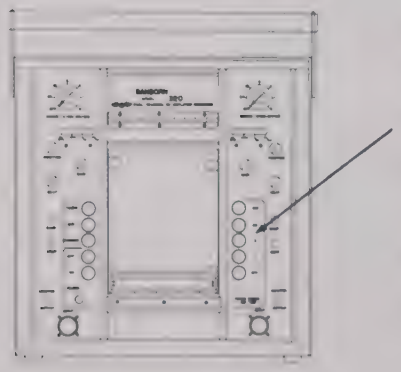
CAL-ZERO-V/CM-MV/MM:

Set the lever switches of both channels to ZERO. This permits setting the no-signal position of the writing arm.



POSITION:

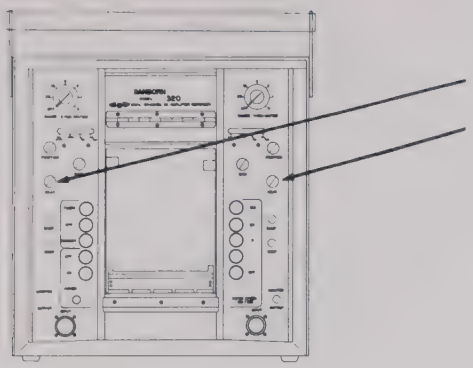
Turn the POSITION controls back and forth while watching the writing arms. It should be possible to move each arm over the entire width of its channel. Adjust the controls to place the arms in the center of each channel.



PAPER SPEED:

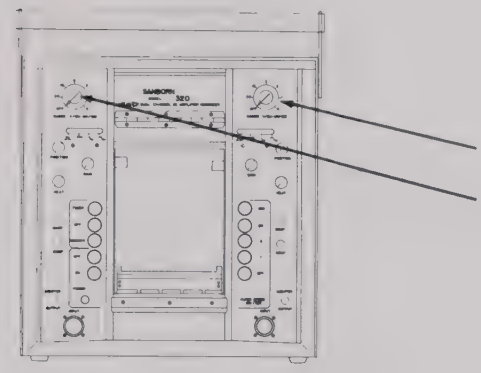
Press the 1 MM/SEC push-button switch; the paper should feed slowly out of the recorder. Next, press the 5, then the 20 and finally the 100 MM/SEC push-buttons; the paper speed should increase with each step. Return the paper speed to 5 MM/SEC.

## 5. OPERATIONAL CHECK (Continued)



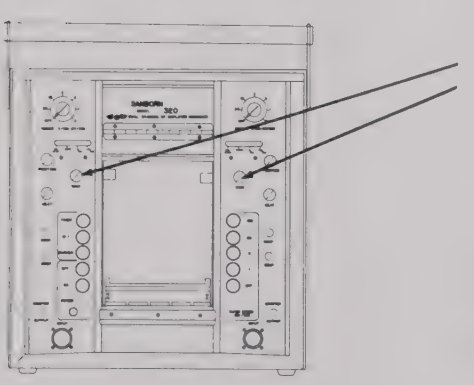
HEAT:

Turn the HEAT controls for both channels to each extreme while watching the baseline formed by the heated stylus. Adjust the controls for a firm, dense black baseline, with clear well-defined edges.



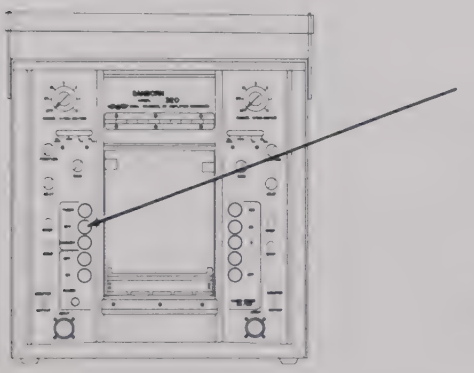
RANGE V/CM-MV/MM:

Rotate the RANGE switches fully clockwise to .5. This is the maximum sensitivity position of these controls.



GAIN:

Turn the GAIN controls of both channels fully counter-clockwise and set the CAL-ZERO-V/CM-MV/MM switches to CAL. Each writing arm will deflect approximately 10 mm. to the left. Slowly rotate the GAIN controls until the writing arms indicate exactly 20 mm. deflection. Record a series of square-waves by switching the CAL-ZERO-V/CM-MV/MM controls between CAL and ZERO.



TIMER-MARKER:

Press the MARKER button; a continuous power line frequency signal will be traced by the marker arm. Now, press the TIMER button; the marker arm will pulse at one-second intervals. Marking and timing may be done simultaneously by pressing both TIMER and MARKER buttons.

## 6. SIGNAL CONNECTION

This recorder includes a guard shield in the input circuit to obtain high common-mode rejection. Signals are connected to the front panel INPUT connector using the table below. After attaching signal leads, reassemble the mating connector for the INPUT socket by inserting the blue terminal assembly into the connector shell so that terminal M and N are next to the key plate, as shown in Figure 10 This allows the internal key to mate with the terminal assembly keyway.

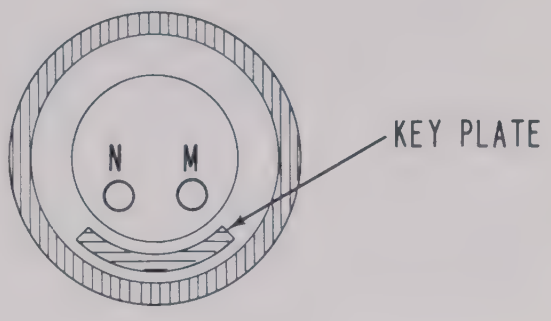
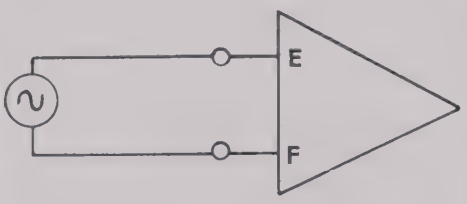
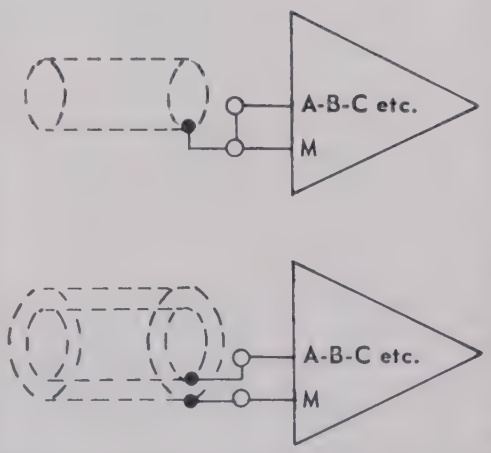
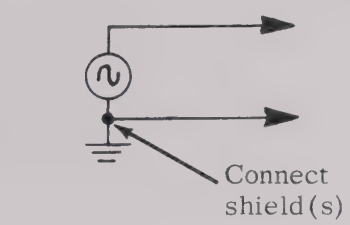
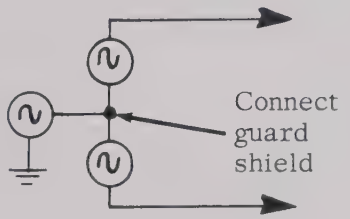
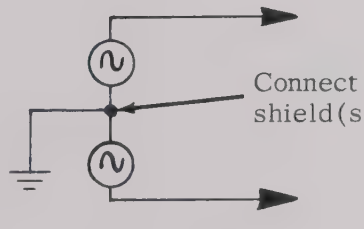
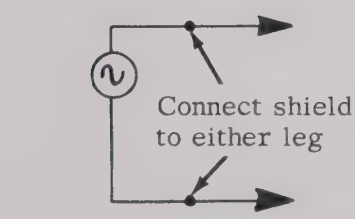
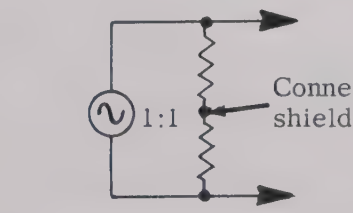



Figure 10

<table>
<tr><td rowspan="3">1. Connect the input signal . . .</td><td rowspan="3"> 
</td><td>When terminal "E" is:</td><td>and terminal "F" is:</td><td>then deflection is:</td></tr>
<tr><td>+</td><td>−</td><td>up-scale</td></tr>
<tr><td>−</td><td>+</td><td>down-scale</td></tr>
<tr><td>2. . . . then connect the shield(s) . . .</td><td> 
</td><td colspan="3">Terminal M is the ground terminal; it always connects to the outer shield of the cable.<br>The remaining terminals (A, B, C, D, H, J, K, L, N) are the guard shield terminals; one of these terminals always connects to the inner (guard) shield, or connects to terminal M if no guard shield is used.</td></tr>
</table>

## 6. SIGNAL CONNECTION (Continued)

| | | |
|---|---|---|
| 3. and finally, connect the shield(s) at the signal source. |  | Single-ended input, one side grounded. |
| |  | Balanced input in presence of common-mode component. |
| |  | Balanced input with no common-mode component. |
| |  | Floating input. Connect shield(s) to either signal leg or connect a 1:1 divider across the signal legs and connect shield(s) at mid-point. Resistors should be matched to within 1%. |
| |  | |

## 7. RECORDING

After making the proper power and signal connections, turn the recorder on and adjust the POSITION controls to center the writing arms on the chart. Calibrate the recorder by setting the RANGE switches to .5 and the CAL-ZERO-V/CM-MV/MM switches to CAL, then adjust the gain controls for exactly 20 millimeters of writing arm deflection. Return the RANGE switch to OFF and set the CAL-ZERO-V/CM-MV/MM switches to V/CM.

Turn the recorder PAPER DRIVE on at the desired recording speed and slowly rotate the RANGE switches clockwise. If the writing arm deflections are too small for accurate interpretation at any setting of the RANGE switch, return this switch to OFF and set the CAL-ZERO-V/CM-MV/MM switches to MV/MM. Rotate the RANGE switches clockwise until the desired deflections are obtained. (Input voltage required for full scale deflection at any setting of the RANGE switch is given in the table below.) To mark or time the recording, press the appropriate push-button.

**WARNING:**

Do not apply over 50 volts (differential) to the input terminals on the MV/MM range or over 500 volts (differential) on the V/CM range. Common-mode voltage tolerence at all positions is ±500 volts.

| RANGE (V/CM) | VOLTS FOR FULL SCALE DEFLECTION AT CALIBRATED GAIN |
|---|---|
| .5 | 2.5 volts |
| 1 | 5 volts |
| 2 | 10 volts |
| 5 | 25 volts |
| 10 | 50 volts |
| 20 | 100 volts |
| **RANGE (MV/MM)** | **MILLIVOLTS FOR FULL SCALE DEFLECTION AT CALIBRATED GAIN** |
| .5 | 25 millivolts |
| 1 | 50 millivolts |
| 2 | 100 millivolts |
| 5 | 250 millivolts |
| 10 | 500 millivolts |
| 20 | 1000 millivolts |

## 8. LOW LEVEL ELECTRICAL PHENOMENA

When measuring extremely low voltages, stray potentials in the external circuit may prevent full use of the amplifier's abilities. These potentials appear on the record or at the MONITOR OUTPUT as a signal which is difficult to distinguish from the value being measured, or as a signal which obscures the value being measured, or as a baseline shift when the RANGE switch is turned.

If the effects of stray potentials are too large to be ignored, one or more of the following procedures will usually reduce the disturbance to manageable proportions:

a. Magnetic coupling can be reduced or eliminated by using an input cable whose conductors are twisted, by reducing the area of any conductor loops in the signal circuit, by isolating the input circuit from varying magnetic fields, or by magnetic shielding of the signal circuit.

b. Capacitive coupling can be controlled by careful static shielding, that is, enclosure of leads in a metallic sleeve which is connected to guard or ground.

c. Any impedance in the input circuit which is common to the input circuit and to some other circuit which carries a current (such as the earth, or a common ground bus, or a structural member used as ground) can introduce a stray signal into the input circuit. This can be reduced or eliminated by proper guarding and grounding.

d. Thermo-electric effects are a common source of stray potentials which must be avoided when operating at high sensitivities. These may be reduced by avoiding contacts which are of dissimilar metals, and by keeping all contacts clean. The entire external circuit should be kept at a uniform temperature.

## 9. MONITORING

Recordings can be monitored with an oscilloscope or other high impedance indicating device by connecting to the front panel MONITOR OUTPUT jack, using the mating connector supplied as an aceessory. The source resistance is 10,000 ohms. A load resistance of one megohm will change recorder calibration by 1%. Lower load resistances will require recalibration. Approximately 40 millivolts/millimeter of deflection is available.

# SECTION 3

# MAINTENANCE

## 1. INTRODUCTION

This section of the instruction manual provides the operator or repair technician with maintenance procedures for this instrument. All adjustments described in this section are factory set. Paragraphs 1 through 6 describe adjustments which may be made with the recorder in its case. Paragraphs 8 through 13 describe adjustments which must be made with the recorder removed from its case.

## 2. POWER FUSE REPLACEMENT

Primary power is supplied to the recorder through a single power fuse, located at the back of the case, near the power cord. (See Figure 11) To install a new fuse place the recorder in its vertical operating position and rotate the fuse cap one-half turn to the left, then lift out. Replace the open fuse with a 1.0 ampere slow-blow fuse (Bussman F02G1R00A). If the fuse continues to open after installing a replacement, inspect the recorder for wiring shorts, faulty components, etc. (See Paragraph 8).

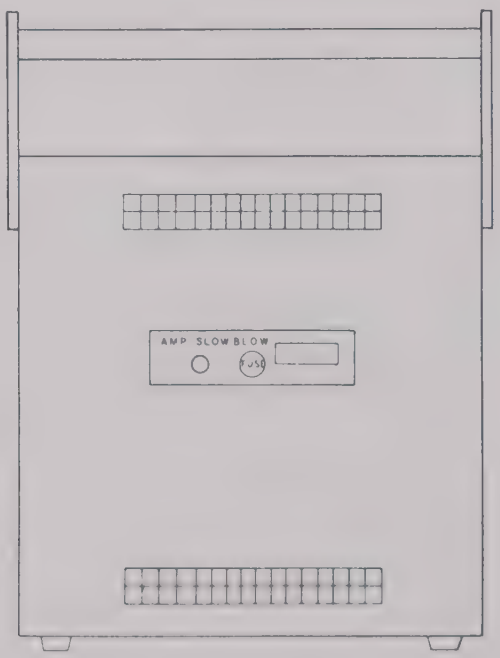



Figure 11

### 3. WRITING ARM MAINTENANCE

This recorder uses three writing arms: the two galvanometer writing arms (Model 398), and the marker arm (Model 401). The galvanometer writing arms are identified by the A-shaped frame attached to the top of the galvanometer. The small nichrome ribbon at the end of the frame, resting on the edge of the paper table, is the writing stylus. There are four adjustments associated with the galvanometer writing arms:

.... The clamping screw which sets the level of the arm and secures it to the galvanometer.
.... The pressure adjustment screw which sets the force of the stylus on the writing edge.
.... The stylus centering adjustment which sets the arm to mechanical center.
.... The writing arm limiters which restrict the travel of the arm to the recording chart.

These adjustments can be identified in Figure 12.

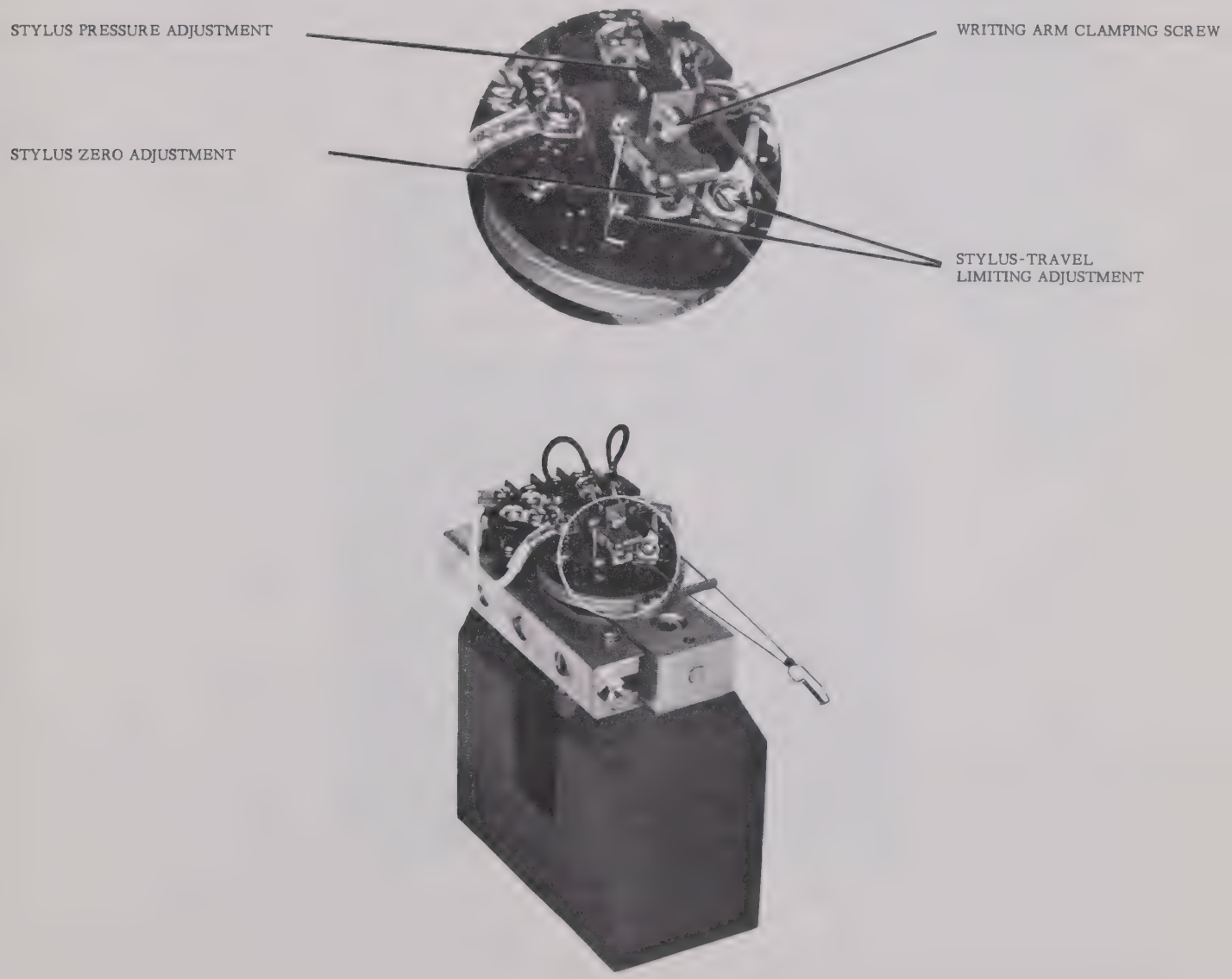



Figure 12

### 3. WRITING ARM MAINTENANCE (Continued)

The need for writing arm maintenance may be indicated by a blurred or indistinct baseline. This will require one or more of the following adjustments.

#### a. STYLUS PRESSURE

Check the pressure of the stylus on the writing edge with the Stylus Pressure Tester Model 442, as shown in Figure 13. This scale is included as an accessory.

To calibrate the scale:

(1) Remove the 2 gram standard from the bottom of the scale and hang it on the scale hook; there is a hole in the standard for this purpose.

(2) Hold the Tester vertical so that the scale hangs free. Slide the index ring to position its top edge opposite the 2 gram mark of the scale.

(3) Remove the standard weight.

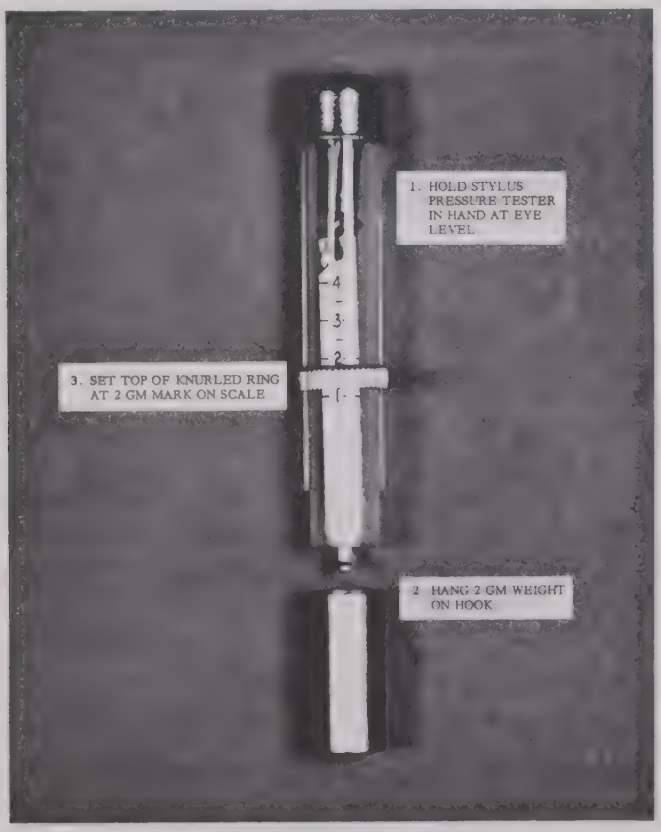

1. HOLD STYLUS PRESSURE TESTER IN HAND AT EYE LEVEL
3. SET TOP OF KNURLED RING AT 2 GM MARK ON SCALE
2 HANG 2 GM WEIGHT ON HOOK
4
3
2

Figure 13

### 3. WRITING ARM MAINTENANCE (Continued)

To adjust the pressure:

Turn off the recorder and lift open the transparent viewing window.

Place the scale hook under the section of the stiff-wire arm nearest the point where the stylus ribbon contacts the Permapaper

Lift the Tester perpendicular to the writing arm so that the scale does not rub against the inner wall of the tube; be sure the stylus is not stuck to the plastic coating of the paper. Read the stylus pressure indicated just as the stylus leaves the paper; it should measure 1.5 to 2 grams. (See Figure 14).

Two holes are provided at the top of the case behind the galvanometers (one for each channel) to allow making adjustments on the stylus pressure adjustment screw. With a long, thin screwdriver inserted through the adjustment hole stylus pressure can be increased by loosening the adjusting screw or decreased by tightening the screw. After making an adjustment, recheck the pressure with the Pressure Tester.

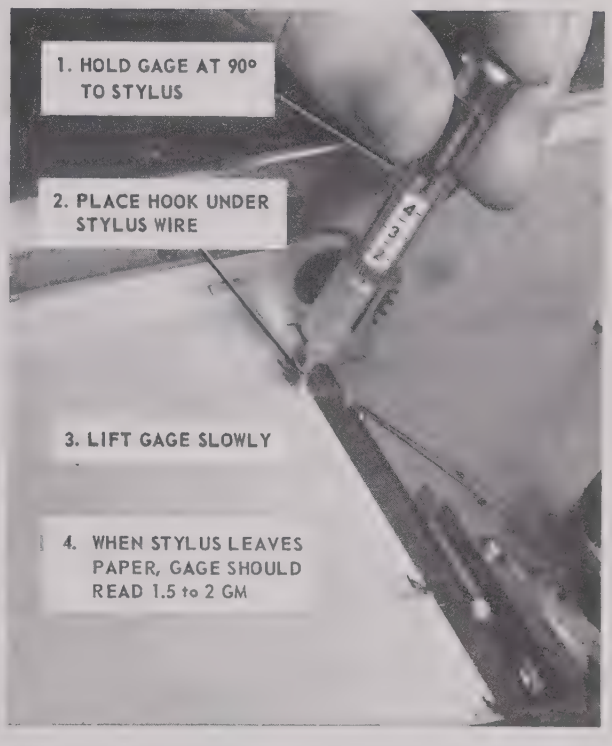

1. HOLD GAGE AT 90° TO STYLUS
2. PLACE HOOK UNDER STYLUS WIRE
3. LIFT GAGE SLOWLY
4. WHEN STYLUS LEAVES PAPER, GAGE SHOULD READ 1.5 to 2 GM

Figure 14

#### b. STYLUS CLEANING

Accumulations of Permapaper coating on the stylus ribbon may prevent clear, well defined recordings. If the ribbon is only lightly coated, it can be burned away by increasing the stylus temperature.

(1) Push the writing table lock lever (at the top left edge of the paper table) toward the galvanometers, releasing the table and lifting the writing arms from the paper.

(2) Turn the paper drive on at its highest speed.

3. WRITING ARM MAINTENANCE (Continued)

(3) Rotate the stylus HEAT control to its maximum clockwise setting and allow the recorder to run for a few moments. The increased temperature may be sufficient to burn off the coating. If the preceding steps do not provide a better trace remove the writing arm.

(4) Loosen, but do not remove, the writing arm clamping screw. (See Figure 12). Lift the arm free, taking care that the magnetic pull does not cause the screwdriver to damage the galvanometer.

(5) Examine the surface of the hot-wire stylus. If the stylus is dirty, clean it by scraping gently with a sharp blade or rub it carefully with fine sandpaper. Do not use steel wool or abrasives containing metal particles. If the ribbon is bent, straighten it with tweezers. Replace the writing arm, tighten the screw, and check the trace. Check the stylus force with the Stylus Pressure Tester.

(6) If the above adjustments do not provide a more clearly defined trace, remove and replace the writing arm with a new one.

(7) If the traces of both channels are blurred, check the Permapaper as it passes over the top of the writing edge. There should be no sign of looseness; the paper should be taut as it passes over the edge so that the stylus has as sharp and small a surface as possible on which to write. If necessary, adjust the paper brake for optimum paper tension. (See Paragraph 6).

c. MECHANICAL CENTERING

When the instrument is turned off, the stylus at the end of each writing arm should be centered in the middle of its ruled chart area, within ±1 millimeter. If adjustment is required, loosen the stylus zero adjustment screw (See Figure 12) using the spline wrench included as an accessory. Move the writing arm to the correct position and tighten the screw.

d. MECHANICAL LIMITING

Each galvanometer is provided with two mechanical stops to prevent peak deflections from causing entanglement of the writing arms, or hooking of the arms on the ends of the writing table. To adjust the stops:

(1) Using a non-magnetic screwdriver, loosen the clamping screw of the galvanometer stop nearest the marker arm. Adjust this stop (slotted holes are provided) to limit writing arm excursion to between one and two millimeters beyond the ruled area for the chart.

### 3. WRITING ARM MAINTENANCE (Continued)

(2) Adjust the remaining stop of this galvanometer and the stops of the other galvanometer to limit writing arm excursions to two millimeters beyond the ruled area of the chart.

(3) Turn on the recorder and rotate each POSITION control from one extreme to the other checking that writing arm travel is within these limits. If not, turn off the recorder and readjust the limiters.

#### e. MARKER ARM

The construction of the marker arm in the right margin of the chart is similar to the galvanometer writing arm. It is attached to a spring arm by a clamp and screw assembly on which is mounted a small coil. A low a-c voltage from the power supply excites the coil to produce line frequency vibrations of the arm.

Procedures described in step b can be used in cleaning this arm. To remove the arm for replacement, remove the two screws which clamp the heater leads to the terminal block and loosen the small clamping screw on the spring arm. After installing a new arm, be sure these screws are tight.

### 4. FREQUENCY COMPENSATION AND DAMPING ADJUSTMENTS

Each channel of the recorder is adjusted for optimum response at high frequencies with its COMPENSATION control (R61) and DAMPING control (R64). These are front panel screwdriver adjustments.

a. Connect a variable frequency audio oscillator to the recorder INPUT connector for the channel under adjustment. Set the frequency of the oscillator to 10 cycles and turn the recorder on.

b. Set the paper speed to 5 mm/second and adjust the stylus HEAT control for maximum heat.

c. Set the DAMPING and the COMPENSATION controls to the approximate centers of their ranges.

d. Adjust the level of the signal or the sensitivity of the channel for a 10 mm. peak-to-peak deflection, centered about the chart center line.

e. Raise the oscillator frequency to 125 cycles while keeping its amplitude constant. Now, adjust the COMPENSATION control to give a 7 mm. peak-to-peak deflection.

## 4. FREQUENCY COMPENSATION AND DAMPING ADJUSTMENTS (Continued)

f. Reduce the oscillator frequency to 45 cycles and adjust the DAMPING control for a peak-to-peak deflection of approximately 9-1/2 mm.

g. Reduce the oscillator frequency to 10 cycles and adjust the signal level to obtain a 10 mm. deflection again.

These adjustments should provide the specified sine wave and transient response. To check the latter:

h. Rotate the RANGE switch to .5, position the writing arm to 10 mm. to the right of center with the POSITION control, and calibrate for 20 mm. across the center of the chart.

i. With paper speed at 20 mm./second and stylus heat adjusted for good definition, throw the lever from ZERO to CAL and back. The trace should rise smoothly to its final amplitude and should not overshoot more that 4% (0.8 mm) if at all. (See Figure 15).

j. If the overshoot is excessive, adjust the DAMPING control to reduce it.

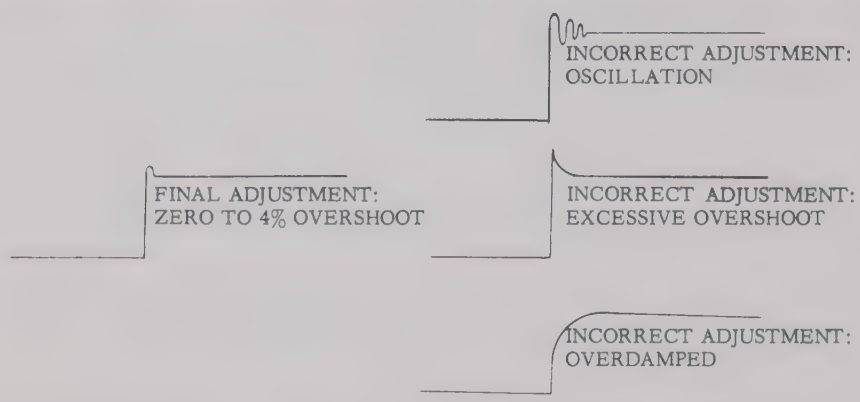



Figure 15

## 5. PARALLAX CORRECTION

Parallax is present when the timing lines of the Permapaper are not parallel to the writing edge. It is important that the entire length of each timing line should cross the edge at the same instant.

To check for parallax:

a. Run off two or three feet of paper at the highest speed. Now, turn the chart drive off so that the paper remains taut over the writing edge.

5. PARALLAX CORRECTICN (Continued)

b. Mark the extreme left and right edge of the paper at the point where it crosses over the edge. Marking may be done by rubbing the surface of the Permapaper where it crosses the edge with a smooth straight object. Be careful that the mark is made with the marking tool crossing the edge at a constant angle; if the marking tool crosses at a variable angle, a false indication of parallax will result.

c. Run the paper a few millimeters to bring the marks into view. They should be on or equidistant within 0. 25 millimeter from the same grid timing line at both extremes of the paper; if they are, the timing lines are parallel to the edge and no corrections are necessary.

d. If parallax does exist, it is caused by the writing edge and a paper supply roll which are not parallel. The first step to take to correct this condition is to try another roll of Permapaper, eliminating the possibility of incorrectly rolled paper.

e. If the preceding step does not correct the error, open the paper table and note the two eccentric stops above the paper spool. The paper table rests on these when closed. Close the paper table and examine it to be sure it is properly seated. Tap the paper table with a metal object evenly along a line parallel to, and one inch in front of, the writing edge. If the sound of the tapping changes from one side to the other, adjust the eccentric stop under the paper table where the tapping sound becomes louder or hollower.

   Lift the paper table and adjust the appropriate eccentric with a large screwdriver until a setting is found at which tapping sound indicates the paper table seats correctly; tighten the hexagonal nut holding the eccentric stop to secure the stop adjustment.

f. Examine the writing edge which clips over the edge of the writing table. If it is not flush with the edge of the table, press in at both ends.

6. PAPER TENSION AND TRACKING ADJUSTMENT

The paper drive is designed to track the Permapaper accurately within limits of ±0.2 5 millimeter. If the chart drifts to one side in its travel over the writing edge make the following checks.

a. When mistracking occurs immediately after inserting the Permapaper, the paper has probably been inserted into the drive at an angle, or has not been centered. This type of mistracking will correct itself in the first few feet of paper run through the drive. If mistracking is present to an excessive degree, roll the paper back and insert it into the drive again with more attention to the loading technique.

### 6. PAPER TENSION AND TRACKING ADJUSTMENT (Continued)

b. Check to see that the paper is riding over the rear brake roller, under the front pressure roller, and is leaving the recorder freely from the front. If the paper is caught under or around either roller, an extra load is placed on the drive mechanism which accentuates any other problems of paper feed or tracking.

c. If the mistracking persists, remove the roll of Permapaper from the spindle and check the end faces of the roll with a straight edge to see if it is perfectly flat. Flatten it if necessary by tamping the convex end face.

d. If mistracking still occurs, or there is a tendency for the paper to tear as a result of too much tension, or the paper passes over the writing edge too loosely to obtain a distinct trace, the braking mechanism located inside the rubber brake roll must be adjusted. Adjustment is made by lifting the paper table and turning a screw at the right hand end of the brake roll. When the screw is brought out toward the end of the roll, the brake tension is decreased. When the screw is turned toward the center of the roll, the tension is increased. Ideal braking is obtained when the paper is tight as it passes over the writing edge.

The brake tension is set at time of manufacture and normally does not require further adjustment. However, when using translucent Permapaper, more tension is required. Readjust the brake when returning to regular paper.

### 7. CASE REMOVAL

To perform the adjustments described in the following paragraphs, it will be necessary to remove the recorder from its two-piece carrying case

a. Place the recorder in its vertical operating position.

b. Remove the four screws from the back of the case and the single screw on each side of the case.

c. Now, carefully lift the outer part of the case away from the inner part. The recorder is not secured to the inner half of the case; for removal, simply lift the recorder out and place on a work bench.

## 8. INSPECTION

a. Blow out both the chassis and the case with an air hose.

b. Clean the panel and the case with a cloth moistened lightly with alcohol or other mild cleaning solution. Wipe dry with a soft, clean cloth. Be careful not to scratch the panel finish.

c. Inspect the recorder for loose components, particularly plug-in components such as transistors, mounting boards, etc.

d. Check that all panel mounted components are securely in place. Check that all controls turn firmly and smoothly.

e. Inspect for damage, visually and by smell. Look for burned or worn insulation, leakage, damaged resistors, capacitors, etc. Inspect for rust, corrosion, etc.

f. Check the paper drive system. First remove the writing arms and the Permapaper. Clean the writing edge and viewing window with a cloth moistened with alcohol or other mild cleaning solution; do not use an abrasive. Inspect the writing arms; if the styli are dirty or misshapen, refer to Paragraph 3 for cleaning and adjustment.

## 9. LUBRICATION

Lubricate the paper drive motor at least every three months with electric motor oil or with SAE-10 motor oil. Do not use rust preventive or cleaning oils. Oil cups are located at both ends of the motor, above the bearings. For continuous duty, more frequent checks are recommended.

Lubricate the gear chain drive and the gear train at least once a year with Anderol L-732. Use a sash brush to apply the lubricant.

Do not over-lubricate; wipe up overflows or spills.

## 10. CALIBRATION CELL REPLACEMENT

Calibration voltage is supplied by a 1.34 volt mercury cell for each channel. The life expectancy of these cells is approximately two years. If it should become impossible to obtain at least 20 millimeters of writing arm deflection when calibrating, remove and replace the cell of the affected channel.

a. Remove the amplifier plug-in board of the channel affected.

b. Remove the guard shield can from the CAL-ZERO-V/CM-MV/MM switch (S2).

c. Identify the cell which is soldered to terminal lugs which are fastened to the printed wiring board. Unsolder and install a fresh cell (Sanborn part number 2A-15A), then reassemble the recorder.

## 11. SUPPLY VOLTAGE ADJUSTMENT

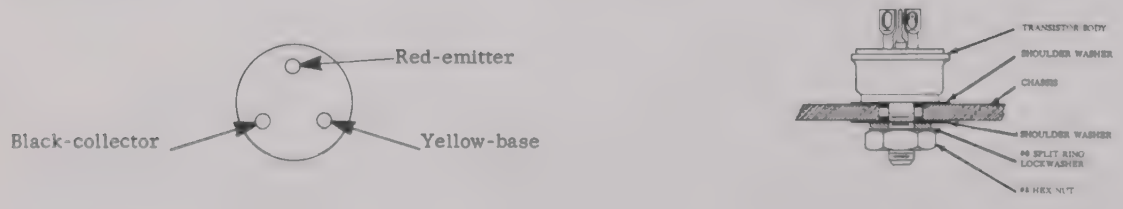
The regulated supply voltages, + and -12 volts d-c, are set with potentiometer R68. This control is located on the power supply plug-in board. Early Model 320 Recorders use plug-in board assembly Model 320-100-C12; later Model 320 Recorders use plug-in board assembly Model 320-100-C24.

a. To adjust regulated supply voltages using Model 320-100-C12 boards:
   (1) Identify screwdriver adjusted potentiometer R68.
   (2) Connect a d-c voltmeter of at least 10,000 ohms-per-volt resistance between chassis ground and the jumper wire adjacent to the board connector.
   (3) Adjust R68 for exactly -12 volts ±0.2 volt.

b. To adjust regulated supply voltages using Model 320-100-C24 boards:
   (1) Identify screwdriver adjusted potentiometer R68.
   (2) Connect the test meter between the test point at the end of resistor R69 (labeled ←12V) and chassis ground.
   (3) Adjust R68 for exactly +12 volts ±0.2 volt.

## 12. TRANSISTOR REPLACEMENT

Transistors used in this instrument are reliable under normal operating conditions. Excessive heat is the most common cause of failure, and in the case of power transistors, is sometimes caused by loose mounting screws. Transistor replacement requires a few precautions. For socket mounted types, be careful that the replacement transistor has its pins properly aligned with its socket holes. Do not force it into the socket; it should go in easily. Also, when replacing two or more transistors simultaneously, be sure to install the transistors in the proper sockets. Replacement of larger transistors, requiring unsoldering of leads, is more critical. Do not allow the soldering iron to overheat the transistor; use a pair of long-nose pliers to grasp the leads and to act as a heat sink. Be sure to mount the replacement transistor securely to the heat sink. Transistor Q13 (2N158) is supplied with color coded leads as shown in Figure 16a. Emitter, base, and collector terminals of output transistors Q18 and Q19 (H5G1) are identified by the letters e, b, and c. Reassemble this transistor as shown in Figure 16b.




a. b.

Figure 16

## 13. PRINTED WIRING BOARD TECHNIQUES

The printed wiring boards used in the Model 320 are the result of many experiments at Sanborn Company to find the best designs consistent with ease in manufacture and servicing. The following procedures will help in making fast, trouble-free removal or replacement of components.

a. Remove the screws which hold each printed wire board to the recorder chassis, then pull the board from its connector, taking care not to damage the components.

b. For amplifier boards, remove the screws holding the shields to the boards.

c. Use as little heat in soldering as possible. A 25 watt soldering iron with a small pointed tip is recommended. Touch the tip of the iron to the lead of the part to be removed, not to the printed board itself. Apply heat to the soldered side of the board - not to the component side.

d. When removing a component, or when tinning a lead, hold the lead itself, next to the body of the resistor, condenser, etc., with pliers, as a heat sink to prevent overheating of the component.

e. Carefully clean and tin the leads of the replacement part. Hold the lead with pliers as described in step d.

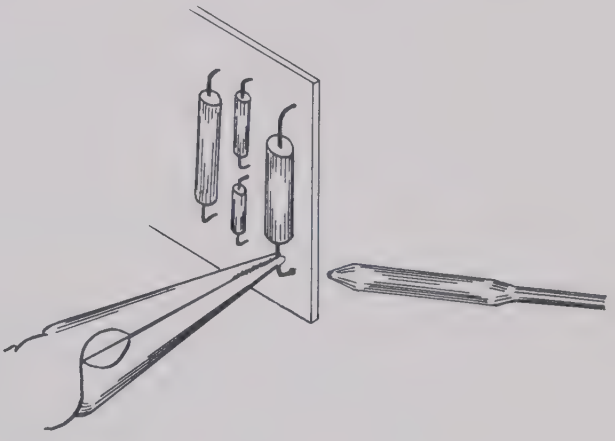


Figure 17

f. Now insert the new part in place through the holes in the printed wire board, with the replacement component held against the board. Carefully solder in place with a minimum of heat, using a pair of long nose pliers as a heat sink adjacent to the replacement part.

g. Replace the shields on the amplifier boards. Carefully insert the printed wire board into its connector; do not bend or use force. Replace the mounting screws removed in step a.

# SECTION 4
# CIRCUIT THEORY

## 1. INTRODUCTION

Each channel of this instrument contains a sensitive and stable recording carrier amplifier. A 1200 cycle transistor modulator in the input circuit reverses the polarity of the input signal 2400 times per second. The resulting output signal is a 1200 cycle amplitude-modulated square-wave. The height of this square-wave is proportional to the amplitude of the input signal; the phase of the square-wave ($0^{o}$ or $180^{o}$), with respect to the excitation signal of the modulator, represents the polarity of the input signal. Conversion of the input signal (which may be d-c or low frequency a-c) to a 1200 cycle square-wave allows the signal to be amplified by an a-c amplifier, avoiding the baseline drift which might otherwise occur in a d-c amplifier of the same sensitivity.

## 2.. GENERAL

This section of the instruction manual is used in conjunction with the schematic and block diagrams found at the rear of the manual. Note that the schematic diagram divides naturally into sections, determined for the most part by printed wiring boards. Only one channel of the instrument is represented on this diagram.

. . . In the lower left-hand corner of the diagram you will find the circuit details of the input and modulator section on assembly 320-100-C30.

. . . To the right of the input circuit may be found the RANGE (attenuator) switch circuit details on assembly 320-100-C3.

. . . At the far right of the diagram is the power supply, oscillator and voltage regulator circuits. This printed wiring plug-in board is common to both channels and is identified as assembly 320-100-C24.

## 2. GENERAL (Continued)

. . . At the top of the diagram, running from left to right, is the heart of the recorder, containing the a-c amplifier, demodulator, and driver amplifier sections. This is a plug-in printed wiring board and is identified as assembly 950-3400.

. . . In the right center of the diagram you will find the circuits for the stylus heat, push-button control, amplifier power output stage, galvanometer and marker, paper drive and timing motor, and power supply circuits.

## 3. COMMON-MODE (IN-PHASE) SIGNALS

Before discussing circuit theory of the amplifier, it is important to describe the signals which may be applied, and show what happens to them.

Assume an amplifier which has two input terminals. Call one terminal "A" and the other terminal "B". The amplifier ideally responds to the voltage between "A" and "B". This voltage between "A" and "B" is the "differential voltage".

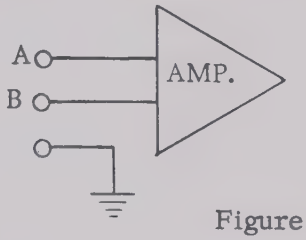



Figure 18

Mathematically, the differential voltage can be expressed as B - A or as A - B. So if terminal "A" is at +1.3 volts, and terminal "B" is at -1.3 volts, this amplifier will respond to the 2.6 volts differential voltage. But now assume that terminal "A" is at +3 volts, and terminal "B" is also at +3 volts. Obviously, the differential voltage is zero. The question is: will the +3 volts at both "A" and "B" interfere with the proper operation of the amplifier? This +3 volts is a "common-mode" or "in-phase" component, because it appears at both input terminals with the same voltage and the same polarity at the same time. Mathematically, the common-mode (or in-phase) component =

$$\frac{(\text{volts at "A"}) + (\text{volts at "B"})}{2}$$

Since the amplifier is intended for differential measurements only, it should ignore this common-mode voltage completely. But no electronic amplifier is perfect, and the common-mode voltage may have some slight effect. The characteristic known as "common-mode rejection" is the figure which shows how perfectly the common-mode component is kept from affecting the amplifier.

### 3. COMMON-MODE (INPHASE) SIGNALS (Continued)

Practical examples of common-mode voltages are: capacitive pickup on input signal cables; a signal circuit which is elevated above or below ground potential because of ground loops; a signal source which inherently includes a common-mode component because of its circuit design, etc.

This amplifier achieves a high common-mode rejection ratio because of its input circuit design. In this amplifier, the input signal is applied to a transformer through a modulator which expresses the input signal as a 1200-cycle square-wave. Any common-mode component is (ideally) applied equally to both terminals of the transformer; as a result, no common-mode component is applied across the primary so as to induce a common-mode component at the secondary. In addition, a dual shield between the primary and secondary of the transformer prevents capacitive coupling of common-mode signal components, between the primary and secondary of the transformer.

These circuit procedures for rejecting common-mode signal components are effective only as long as a portion of the common-mode does not become transformed in some way into a differential signal; if this happens, then the amplifier is unable to discriminate against this differential component, but will amplify it along with any of the other differential signals which the amplifier is designed to accept.

The cause and cure for this problem is discussed in the following paragraph.

### 4. GUARD SHIELD THEORY

The preceding paragraph showed that the amplifier will reject common-mode signals except for any part of the common-mode signal which may become transformed into a differential signal before it reaches the amplifier input terminals. This paragraph shows how a part of the common-mode signal can be changed into a differential signal, and what to do to prevent it.

Assume a signal source connected to the amplifier as in Figure 19:

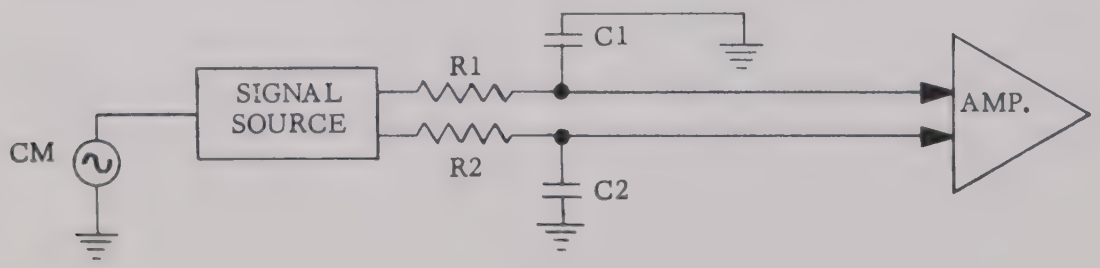



Figure 19

## 4. GUARD SHIELD THEORY (Continued)

With this circuit, CM is the common-mode signal, R1 and R2 are the series resistances of the two sides of the signal source and the cabling (the general case would use Z1 and Z2 as the two source impedances), and C1 and C2 are the cable and stray capacitances of the two sides of the signal source and cabling.

In the upper lead, R1 and C2 form a low pass filter, so that (when CM is an a-c signal) only a portion of CM appears at the upper terminal of the amplifier. Similarly, R2 and C2 form another low pass filter, so that only a portion of CM appears at the lower terminal of the amplifier. These portions may be large or small.

Now, if the two sides of the circuit are perfectly balanced (R1 = R2, C1 = C2) then the portion of CM which appears at the upper terminal is exactly the same as the portion of CM which appears at the lower terminal: the common-mode signal remains a pure common-mode signal, which the amplifier is designed to reject.

However, if the two sides of the circuit are not perfectly balanced, then the portion of CM which appears at the upper terminal is no longer exactly the same as the portion of CM which appears at the lower terminal; we have transformed a part of the common-mode signal into a differential signal, which the amplifier will not reject, but will treat as any other differential signal. This spoils the apparent common-mode rejection ratio. The same effect occurs with d-c signals, where the unbalance lies in R1 and any leakage resistance in parallel with C1, compared with R1 and the leakage resistance across C2.

What is needed here is a method of keeping an unbalanced signal source from transforming a portion of the common-mode voltage into a differential voltage. This is done with a guard shield.

The guard shield circuit uses two shields: an inner shield, connected to the common-mode voltage, and an outer shield, connected to the amplifier ground, as shown in Figure 20.

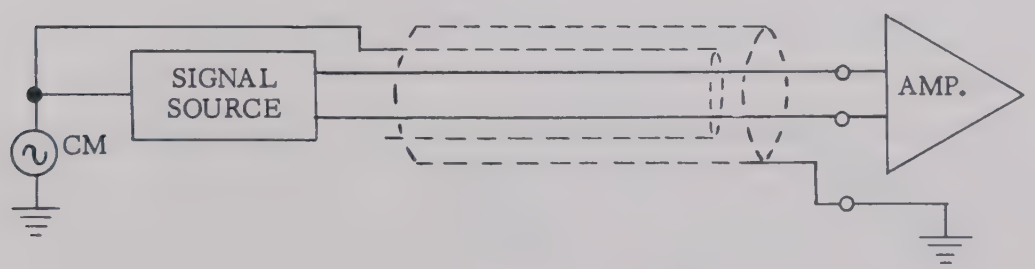



Figure 20

4. GUARD SHIELD THEORY (Continued)

With this inner shield connected, no current will flow through the stray capacitances and cable capacitances because both sides of the capacitances are at the same common-mode potential.

The equivalent circuits showing the resistances and the capacitances are shown in Figure 21.

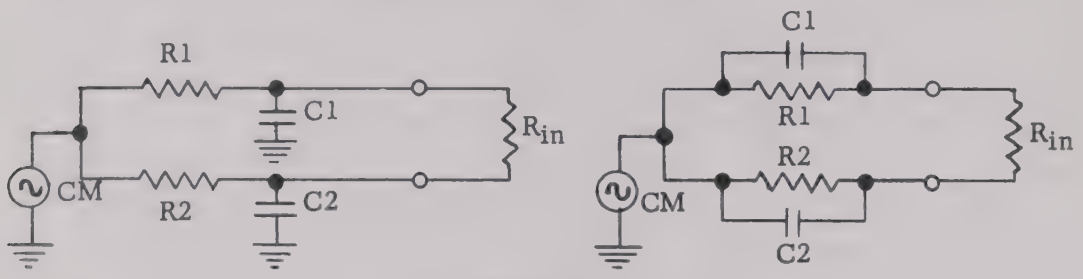



Figure 21

Without guard shield: resistance and capacitance unbalance cause a differential voltage to appear across amplifier input $R_{in}$.

With guard shield: resistance and capacitance unbalance can no longer cause a differential voltage to appear across amplifier input $R_{in}$.

5. INPUT

The input circuit of this amplifier includes a four-position function switch (CAL-ZERO-V/CM-MV/MM) and a transistor modulator consisting of Q14, Q15, Q16, Q17 and transformer T2.

The function switch operates as a balanced attenuator, offering two primary ranges of sensitivity. Signals applied to the switch through terminal E of the front panel INPUT connector J1 are fed to the emitters of Q16 and Q17 of the modulator; signals applied to terminal F of J1 are fed to the emitters of Q14 and Q15.

The modulator transistors are driven by the excitation voltage supplied by the oscillator circuit, and coupled to the bases of the transistors through transformer T2. The modulator reverses the polarity of the input signal 2400 times per second. The resulting output is a 1200-cycle square-wave signal applied to the input transformer T3 which couples the signal to the first stage a-c amplifier.

In the CAL position, the emitters of Q16 and Q17 are removed from the input signal and instead connect to a 10 millivolt d-c calibration voltage derived from calibration cell BT-1 and resistors R47, R48 for amplifier gain adjustments.

The ZERO position of the function switch ties the emitters of the modulator transistors together so that a reference or baseline may be established with the POSITION control.

### 6. INPUT AMPLIFIER

The two-stage input amplifier consists of transistors Q1 and Q2 and associated components. The input signal is applied to the base of Q1; the output signal from the collector of Q1 is direct-coupled to the base of Q2. A negative voltage feedback loop between the collector of Q2 and the emitter of Q1 stabilizes the a-c gain of the circuit. Blocking capacitors C3-C6 prevent changes in feedback from disturbing d-c voltage conditions of the two stages.

### 7. GAIN AND RANGE CONTROLS

The GAIN (sensitivity) and RANGE (attenuator) control circuits are physically located on the front panel of the recorder.

a. The GAIN control is effective for all positions of the RANGE switch. Moving this control changes the amount of signal voltage fed from the output of Q2 to the input of Q3.

b. The RANGE switch is divided into two circuits. In the .5, 1, and 2 positions, the change in overall gain required for attenuation is provided by varying the amount of feedback in the loop between Q2 and Q1. In the 5, 10, and 20 positions, the change in overall gain required for attenuation is provided by varying the amount of feedback in the loop between the collector of Q5 and the base of Q3.

### 8. THREE-STAGE AMPLIFIER

The three-stage amplifier section Q3, Q4, and Q5 amplifies the signal from the input amplifier Q1-Q2 and drives the demodulator transformer T1. This direct-coupled transistor amplifier includes the following special features:

a. The input signal to Q3 includes two components; the (nominally) square-wave component from Q2, and the sine-wave component from the POSITION control R60. Note that either component may be at $0^{\circ}$ or $180^{\circ}$ phase relation to the a-c voltage from the reference source; the phase relation is interpreted by later circuits to provide an up-scale or down-scale deflection by the galvanometer writing arm.

b. The amplifier includes a d-c negative voltage feedback loop which is connected from the emitter of Q5 back to the emitter of Q3. The function of this loop is to stabilize the d-c operating voltages of this section of the amplifier.

c. The amplifier also includes an a-c feedback loop which is connected from the collector of Q5 back to the base of Q3. The function of this loop is to stabilize the signal gain of the amplifier against changes in component characteristics, supply voltages, etc.

## 9. POSITION CONTROL

The POSITION control is physically located on the front panel of the recorder. Electrically it is located across the ten-volt a-c reference line which also drives the modulator transistors. The voltage from this potentiometer is zero near the mid-point of the control, rises to a maximum at one extreme of the control, and to a similar maximum but $180^{o}$ removed, at the other extreme. This voltage adds to the signal voltage applied to Q3 to give an output component from the demodulator for positioning the galvanometer writing arms.

## 10. DEMODULATOR AND FILTER

The demodulator, which includes transistors Q6 and Q7, center-tapped transformer T1, and the input capacitor of the filter, is a full-wave, phase-sensitive, synchronous peak detector. Circuit operation is shown in Figure 22.

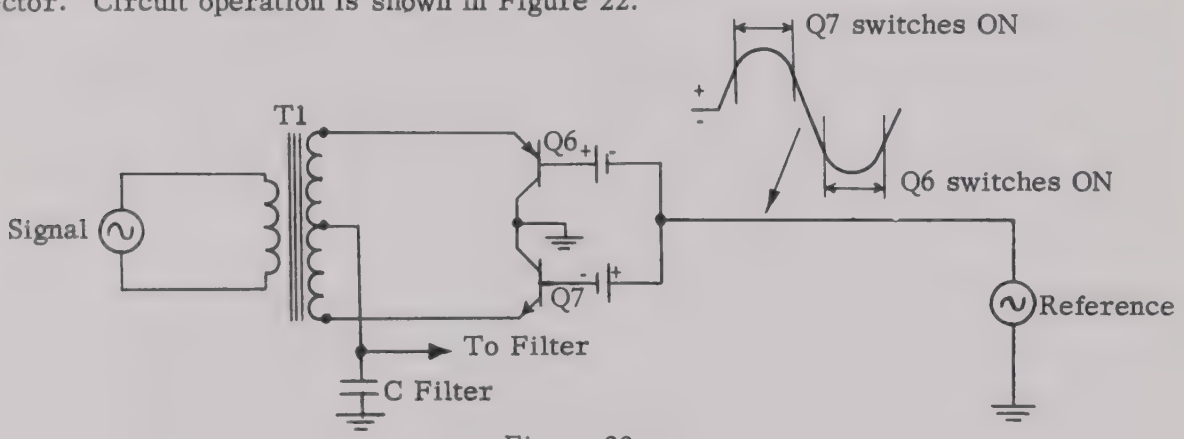



Figure 22

With no signal or reference applied, transistors Q6 and Q7 remain off and appear as a pair of open switches because of the reverse bias applied to each transistor. ( The bias is shown here as a battery; the actual biasing voltage is taken from the positive and negative regulated supplies through a resistance network).

With a reference only applied, Q6 and Q7 turn on and off alternately, and approximate a pair of perfect switches which open and close in synchronism with the reference voltage. The "ON" period occurs about the peak of the positive (Q7) and negative (Q6) reference voltage waveform. An essentially perfect switching characteristic is obtained because (1) the voltage interval between transistor-OFF and transistor-ON corresponds to a small time interval, and because (2) the emitter-collector circuit being switched has an extremely high "OFF" impedance (provided by the reverse bias) and an extremely low "ON" impedance (because of the common-collector transistor circuit).

### 10. DEMODULATOR AND FILTER (Continued)

If a signal is now applied to the demodulator, in-phase or 180° out-of-phase with the reference, then one transistor or the other will contribute the larger amount of output. This results in a net d-c output, plus ripple components, where the d-c component has an amplitude proportional to the amplitude of the signal, and a polarity which represents the phasing between signal and reference. If, on the other hand, the signal should be at a time quadrature with the reference, then the two transistors contribute equally to the output, resulting in ripple components only, with no net d-c output. If an in-phase and a quadrature signal are present at the same time, the demodulator will respond to the in-phase component and almost completely ignore the quadrature component.

The filter which follows the demodualtor is a conventional low-pass R-C filter with output to the limiter circuit, front panel MONITOR OUTPUT jack and to the input of the driver amplifier (Q10).

### 11. LIMITER

Output signals from the demodulator are fed to the MONITOR OUTPUT jack and to the limiter stage. The MONITOR OUTPUT jack provides a convenient means for observing the signal waveform on an oscilloscope. The source resistance at this point is 10,000 ohms. A load resistance of 1 megohm will change the calibration of the recorder by 1%. Lower load resistances will require recalibration. Approximately 40 millivolts/millimeter of deflection is available.

The limiter consists of transistors Q8, Q9 and associated components. The transistors are connected in a complementary circuit, with the input signal supplied to the emitters, the collectors grounded and the operating bias on the bases taken from the regulated + and -12 volt supplies through a resistance network. The bias voltage acts as a reference against which the signal voltage is compared. When the level of the input signal exceeds the reference voltage, in either a positive or negative direction, the appropriate transistor effectively becomes a low resistance and clamps the signal at the level set by the reference voltage. This reference voltage is selected to limit writing arm excursions to approximately 115% of full scale.

### 12. DUAL AMPLIFIER

The signal from the limiter is fed to the dual amplifier which includes transistors Q10, Q11 and associated components. Transistors Q10 and Q11 may be considered as one stage having two inputs and a single output.

12. DUAL AMPLIFIER (Continued)

a. The first input signal originates as the output from the limiter; this signal is applied to emitter-follower Q10. The output from this transistor is taken from the emitter and fed to Q11 as a signal input.

b. The second input originates as a feedback voltage from the galvanometer and includes both current and velocity feedback components.

The output signal is taken from the collector of Q11. This output includes three components of interest:

c. The signal, originally supplied to the base of Q10, which represents the input signal to the amplifier.

d. The current feedback signal, originating as the voltage developed across the series resistor R27 by the drive current through the signal winding of the galvanometer.

e. The velocity feedback component generated in the feedback winding of the galvanometer coil by its motion through the magnetic field.

Note that Q11 is a part of the overall feedback loop which includes the transistors which follow it in sequence of signal flow, and the entire electro-mechanical vibrating system of the galvanometer.

13. DC AMPLIFIER AND OUTPUT STAGE

DC amplifier Q12 and Q13 is a conventional two-stage transistor amplifier. Input (from Q11) is applied to the base of Q12. Output is taken from both the emitter and collector of Q13. These two outputs are of opposite phase and are of different amplitudes so as to properly drive the output stage Q18 and Q19 which follows.

The base of Q18 is driven from the collector of Q13, and the base of Q19 is driven from the emitter of Q13. Output from this amplifier (Q18-Q19) feeds the single-ended driving section of the galvanometer coil.

14. GALVANOMETER

The recording galvanometer used in this instrument is similar to the classic D'Arsonval movement, used in most d-c meters. However, it differs in several important particulars.

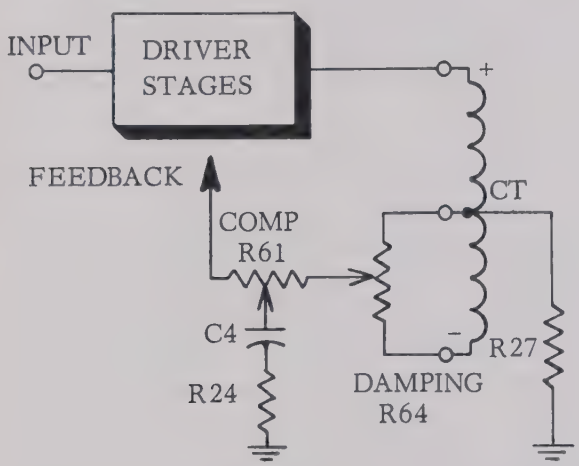
First, in order to operate at high writing speeds, an extremely stiff suspension is required to provide sufficient restoring force to the writing arm.

**14. GALVANOMETER (Continued)**

Second, in order to generate the forces necessary to operate with such a stiff suspension, the coil is many times larger and heavier than comparable elements of a conventional moving coil meter.

Third, because it requires large forces to move the heavy coil, the magnetic structure is of tremendous size and strength by comparison with other D'Arsonval movements.

Finally, to provide the required galvanometer damping, the coil is constructed with two windings; an inside winding which carries the currents to drive the coil, and an outside winding which generates a feedback voltage which is returned to the driver amplifier for damping.




Note: the upper portion of the coil between + and CT carries the current which drives the coil into motion. The lower portion of the coil between CT and - generates a voltage proportional to the instantaneous velocity of the coil. (The a-c component induced by the transformer action of these coils may be ignored.)

Figure 23

Galvanometer damping may be achieved by two methods: mechanical or electrical. Analysis of mechanical damping shows that it is equivalent to applying a force to the coil which is proportional to the instantaneous velocity of the coil but in direct opposition to that velocity. A mechanical device could be designed to provide any degree of damping; however, it would be difficult to adjust and maintain.

Since mechanical damping is impractical, this galvanometer uses electrical means to damp coil motion. Electrical damping requires an electrical signal, proportional to the instantaneous velocity of the coil, which is applied to the amplifier so as to oppose the velocity. The velocity voltage generated by the coil is used for this purpose.

The galvanometer and the driver amplifier are included within one feedback loop. The feedback voltage contains two components:

a. Current feedback component, originating as the voltage developed across the series resistor R27 by the drive current through the signal winding of the galvanometer.

## 14. GALVANOMETER (Continued)

b. Velocity feedback component, generated in the feedback winding of the galvanometer coil by its motion through the magnetic field. This voltage is proportional to the instantaneous velocity of the coil.

These feedback voltages are returned to the driver amplifier with such an electrical phasing as to oppose the signals which cause the galvanometer to move.

The function of the current feedback component is to keep the current through the signal winding of the coil independent of temperature changes in the galvanometer or drive circuit.

The function of the velocity feedback component is to allow galvanometer damping adjustments by electrical means. For best operation, galvanometer damping is adjusted to simulate 100% of critical. At this value the writing arm will reach its final stable value in a minimum of time in this circuit.

In this combination of driver amplifier and galvanometer, the DAMPING control R64, located in the feedback loop from the galvanometer, is adjusted so that the largest part of the damping is supplied by the signal generated in the velocity coil of the galvanometer. Both feedback components are adjusted by the COMPENSATION control R61 to complement the high frequency roll-off characteristics of the galvanometer. The latter adjustment serves to extend the response of the system beyond that of the galvanometer alone.

A smaller additional amount of damping is supplied by the coil frame of the galvanometer. This frame forms a complete closed-loop circuit, equivalent to a low-resistance, one-turn, short-circuited winding on the coil frame. The forces developed in this frame are proportional to the coil velocity, and are in such a direction as to reduce the coil velocity. This is exactly the relationship needed to damp coil motion.

## 15. POWER SUPPLY

The power supply consists of a transformer with a single low voltage, high current secondary winding, using a dual rectifier and filter network to provide output voltages which are equal in magnitude but of opposite polarity. These voltages are supplied to the driver and power output stages of the amplifier, and to the voltage regulating circuit which provides stable voltages to critical circuits in the amplifier.

## 16. VOLTAGE REGULATOR AND OSCILLATOR

Two separate voltage regulating circuits are mounted on plug-in board Model 320-100-C24. These are conventional series regulating circuits. In the positive supply, regulator transistor Q20 is in series with the current flowing through the load. Electrically, the regulator acts as a voltage dropping resistance because there is current flowing through it and a voltage drop across it. The effective resistance is controlled by changes in its base to emitter voltage. This is the basic principle of voltage regulation.

The regulator tries to keep the output voltage constant, independent of any change in the load current or of changes in the rectified d-c voltage from the rectifiers. A portion of the output voltage will appear at the base of control amplifier Q21 (the emitter of which is referenced by Zener diode CR11), and cause an amplified change of voltage to appear at its collector. Because the collector of Q21 is connected directly to the base of Q20, there will be a change in the base to emitter voltage of Q20 which changes the voltage drop across that transistor so as to oppose the original change in output voltage. Output from this circuit is adjusted to +12 volts by R68.

Operation of the negative regulated supply is similar with exception of the reference voltage for the control amplifier. This voltage is taken from the +12 volt supply. In this way, adjusting the +12 volt supply with potentiometer R68 simultaneously sets the -12 volt regulated supply.

Some instruments use a slightly different regulating circuit, however, operation is essentially the same. Potentiometer R68 is located in the negative regulating circuit and adjusting this control for -12 volts will simultaneously set the positive regulated supply to +12 volts. This regulator plug-in board is identified as assembly 320-100-C12. (See Paragraph 11, Maintenance Section).

A push-pull oscillator circuit, consisting of Q24, Q25 and associated components is also mounted on the regulator board. The operating frequency of this circuit is 1200 cycles. The output from the oscillator is supplied to the modulator, position control, and demodulator circuits.

## 17. TROUBLE SHOOTING HINTS

Trouble shooting procedures for the Model 320 are in most respects similar to those used on any electronic equipment. The technician will find that this instrument readily lends itself to the substitution method of locating defects due to the many plug-in assemblies and components which may be inter-changed from channel to channel. This is particularly helpful in locating defects which are confined to a single channel.

## 17. TROUBLE SHOOTING HINTS (Continued)

Using an ohmeter:

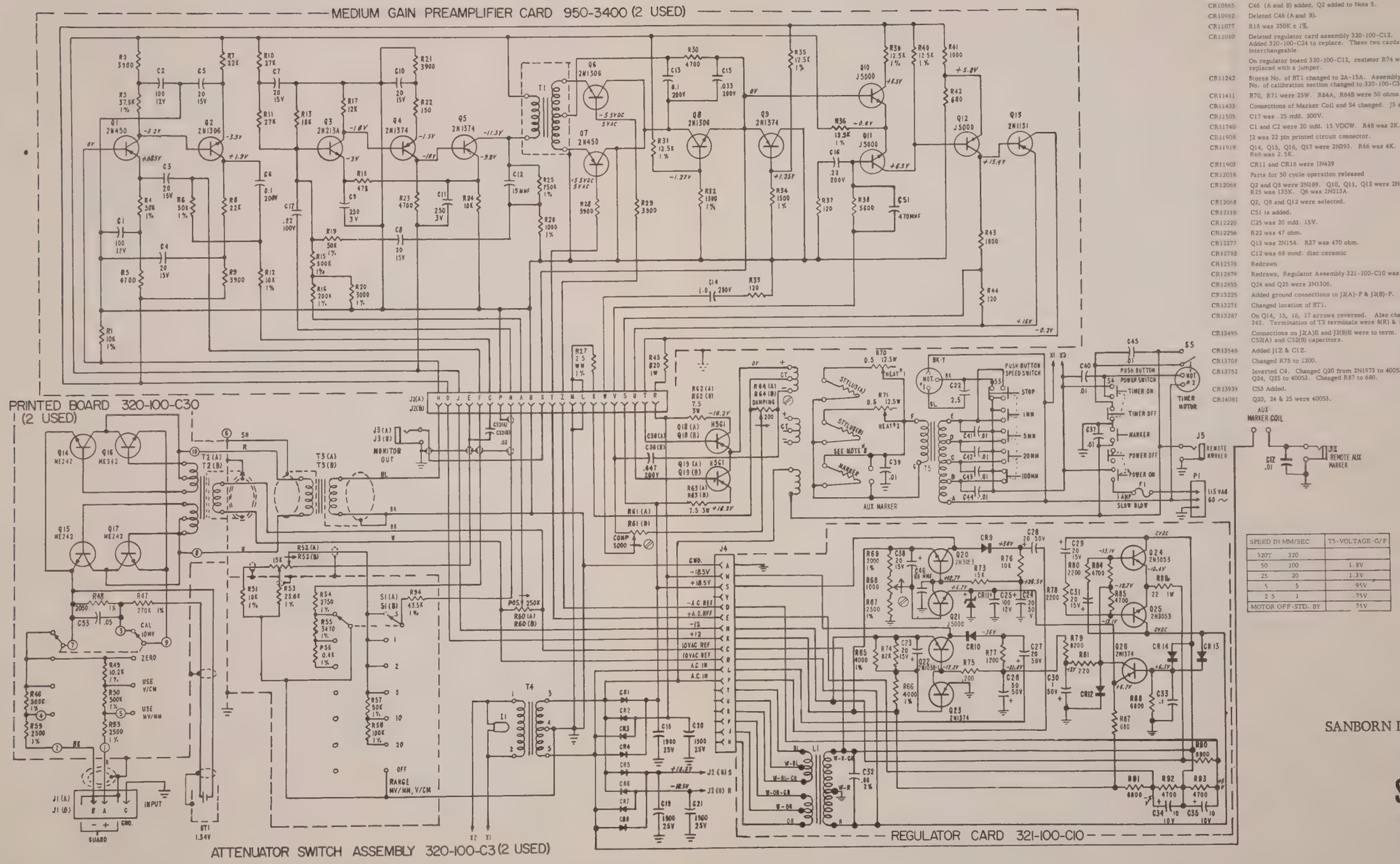
When checking for open circuits on any of the amplifier assemblies, be sure to remove the transistors associated with that circuit before making the check. If possible, remove the entire printed wire assembly if it is of the plug-in type. Never use an ohmeter to check transistors as the voltage applied may "punch through" and consequently permanently damage the transistors. When making checks of precision resistors, use a good electronic meter of 3% full scale accuracy.

Single-Channel Defects:

Single-channel defects are readily isolated by the substitution method. Since both channels use identical plug-in components (i.e. transistors, batteries, etc.) simply interchange components from the channel which is working to the faulty channel.

| | |
|---|---|
| Transistors: | All transistors may be interchanged from channel to channel. Q10 - Q11, Q14 - Q17 (matched pairs) and Q1 - Q12 may only be replaced with their counter-parts in the working channel. Before changing transistors, be sure to turn the recorder off. |
| Batteries: | Calibration batteries are the same for both channels. If both batteries are suspected to be faulty, replace with fresh batteries. |
| Galvanometer: | To check a suspected galvanometer, simply interchange galvanometer leads on the terminal block at the top of the galvanometer. Be sure to note the color code of the leads. |
| Checking voltages: | When making voltage checks on any part of the amplifiers, use a voltmeter of at least 10,000 ohms-per-volt resistance. To set the + and - supply voltages (12 volt), refer to Paragraph 13 of Section III. |
| Stylus Heat: | Insufficient stylus heat may be caused by any one of the following factors: |

| | |
|---|---|
| Carbon deposit from the slider arm of the stylus heat potentiometer. | Carefully clean the wire surface with non-toxic cleaning fluid. |
| Poor contact at the writing arm clamp. | Remove the writing arm, clean the contact surface and re-clamp securely. |
| Open stylus ribbon. | Replace with new writing arm. |
| Loose heater leads at galvanometer mounting block. | Tighten all terminal screws securely. |




| CHANGES | | |
|---|---|---|
| CR10775 | Note 5 revised. Note 8 added. R72, R82, R86 & C30 deleted R49 was 10.4K, R69 was 3750, CR15 & CR16 added. TM-1 removed. Shield connections changed. C39, C40, C41, C42, C43, C44 & C45 added. | 5/25/60 |
| CR10846 | Q6 was 2N169. | 6/16/60 |
| CR10865 | C46 (A and B) added, Q2 added to Note 5. | 6/17/60 |
| CR10982 | Deleted C46 (A and B). | 8/4/60 |
| CR11077 | R16 was 250K ± 1%. | 10/6/60 |
| CR11080 | Deleted regulator card assembly 320-100-C12. Added 320-100-C24 to replace. These two cards are interchangeable. | 9/23/60 |
| | On regulator board 320-100-C12, resistor R74 was replaced with a jumper. | 10/14/60 |
| CR11242 | Stores No. of BT1 changed to 2A-15A. Assembly No. of calibration section changed to 320-100-C30. | 12/1/60 |
| CR11411 | R70, R71 were 25W. R64A, R64B were 50 ohms. | 1/31/61 |
| CR11433 | Connections of Marker Coil and S4 changed. J5 added. | 2/2/61 |
| CR11505 | C17 was .25 mfd. 200V. | 3/21/61 |
| CR11740 | C1 and C2 were 20 mfd. 15 VDCW. R48 was 2K. | 8/31/61 |
| CR11908 | J2 was 22 pin printed circuit connector. | 8/31/61 |
| CR11919 | Q14, Q15, Q16, Q17 were 2N393. R66 was 4K. R69 was 2.5K. | 9/7/61 |
| CR11903 | CR11 and CR16 were 1N429 | 8/14/61 |
| CR12038 | Parts for 50 cycle operation released | 9/14/61 |
| CR12068 | Q2 and Q8 were 2N169. Q10, Q11, Q12 were 2N169. R25 was 135K. Q6 was 2N213A. | 10/2/61 |
| CR12068 | Q2, Q8 and Q12 were selected. | 10/2/61 |
| CR12116 | C51 is added. | 11/21/61 |
| CR12220 | C25 was 20 mfd. 15V. | 12/11/61 |
| CR12256 | R22 was 47 ohm. | 2/14/62 |
| CR12277 | Q13 was 2N158. R37 was 470 ohm. | 2/14/62 |
| CR12782 | C12 was 68 mmf. disc ceramic | 7/26/62 |
| CR12578 | Redrawn | 4/9/62 |
| CR12879 | Redrawn, Regulator Assembly 321-100-C10 was 320-100-C24. | 9/4/62 |
| CR12955 | Q24 and Q25 were 2N1306. | 10/8/62 |
| CR13225 | Added ground connections to J2(A)-P & J2(B)-P. | 1/26/63 |
| CR13271 | Changed location of BT1. | 1/30/63 |
| CR13287 | On Q14, 15, 16, 17 arrows reversed. Also changed S628 to 242. Termination of T3 terminals were 8(R) & 10(W). | 2/9/63 |
| CR13495 | Connections on J2(A)E and J2(B)E were to term. C. Added C52(A) and C52(B) capacitors. | 5/10/63 |
| CR13548 | Added J1Z & C1Z. | 5/14/63 |
| CR13709 | Changed R75 to 1200. | 8/5/63 |
| CR13752 | Inverted C4. Changed Q20 from 2N1973 to 40053. Changed Q24, Q25 to 40053. Changed R87 to 680. | 8/5/63 |
| CR13939 | C53 Added. | 11/19/63 |
| CR14081 | Q20, 24 & 25 were 40053. | 1/10/64 |

| SPEED IN MM/SEC | | T5-VOLTAGE-G/F |
|---|---|---|
| 320T | 320 | |
| 50 | 100 | 1.8V |
| 25 | 20 | 1.3V |
| 5 | 5 | 95V |
| 2.5 | 1 | 75V |
| MOTOR OFF-STD. BY | | 75V |

SANBORN DUAL CHANNEL DC AMPLIFIER RECORDER
MODELS 320, 320T
SCHEMATIC: 320-100-C1 SUB 34

SANBORN COMPANY
WALTHAM MASS.
MARCH 1964
CR14081 RPL-320-6

| SYMBOL | DESCRIPTION | SANBORN NO. | VENDOR CODE |
|---|---|---|---|
| BT1A, B | Battery, mercury (A) 1.35V | 2A-15A | (SAN) |
| C1 | 100 mfd. 12V | 8C-74 | NLW288(CD) |
| C1Z | .01 mfd. disc ceramic | 8E-6 | 29C214A1(SPR) |
| C2 | 100 mfd. 12V | 8C-74 | NLW288(CD) |
| C3 | 20 mfd. 15 VDCW | 8C-61 | TE1157(SPR) |
| C4 | 20 mfd. 15 VDCW | 8C-61 | TE1157(SPR) |
| C5 | 20 mfd. 15 VDCW | 8C-61 | TE1157(SPR) |
| C6 | 1 mfd. 200V | 8B-66 | NLW341(CD) |
| C7 | 20 mfd. 15 VDCW | 8C-61 | TE1157(SPR) |
| C8 | 20 mfd. 15 VDCW | 8C-61 | TE1157(SPR) |
| C9 | 250 mfd. 3 VDCW | 8C-60 | TE1065(SPR) |
| C10 | 20 mfd. 15 VDCW | 8C-61 | TE1157(SPR) |
| C11 | 250 mfd. 3 VDCW | 8C-60 | TE1065(SPR) |
| C12 | 15 mmf ± 10% | 8E-14 | ED-15(ER) |
| C13 | .1 mfd. 200V | 8B-66 | NLW341(CD) |
| C14 | 1.0 mfd. 200V | 8B-31 | ML(AST) |
| C15 | .033 mfd. 200V | 8B-118 | 621M(GA) |
| C16 | .22 mfd. 200V | 8B-52 | 621(GA) |
| C17 | .22 mfd. 100V | 8B-131 | M150-224(EPC) |
| C18 | 1900 mfd. 25 V | 8C-45MS | KP(CD) |
| C19 | 1900 mfd. 25 V | 8C-45MS | KP(CD) |
| C20 | 1900 mfd. 25 V | 8C-45MS | KP(CD) |
| C21 | 1900 mfd. 25 V | 8C-45MS | KP(CD) |
| C22 | 2.5 mfd. 330V (with bkt.) | 8B-117 | KGNU3025(CD) |
| C23 | 20 mfd. 15 V | 8C-61 | TE1157(SPR) |
| C24 | 20 mfd. 50V | 8C-66 | NLW341(CD) |
| C25 | 100 mfd. 12 V | 8C-74 | NLW288(CD) |
| C26 | 50 mfd. 50V | 8C-54 | 30D200(SPR) |
| C27 | 20 mfd. 50V | 8C-66 | NLW341(CD) |
| C28 | 20 mfd. 50V | 8C-66 | NLW341(CD) |
| C29 | 20 mfd. 15 V | 8C-61 | TE1157(SPR) |
| C30 | 1 mfd. 50V | 8PC-15 | ECPA1003(CD) |
| C31 | 20 mfd. 15 V | 8C-61 | TE1157(SPR) |
| C32 | 100 mfd. + 25 50 V | 8B-123 | WMF(CD) |
| C33 | 1 mfd. 100 V | 8B-129 | BE1A104K(EPC) |
| C34 | 10 mfd. 10 V | 8C-35 | NLW256(CD) |
| C35 | 10 mfd. 10 V | 8C-35 | NLW256(CD) |
| C36A, B | .047 mfd. 20% 200V mylar | 8B-58 | 621M(GA) |
| C37 | .01 mfd. disc ceramic | 8E-6 | 29C214A1(SPR) |
| C38 | 20 mfd. 15 V | 8C-61 | TE1157(SPR) |
| C39 thru C45 | .01 mfd. disc ceramic | 8E-6 | 29C214A1(SPR) |
| C46 | 68 mmf. | 8E-21 | ED-68(ER) |
| C51 | 470 mmf. | 8E-9 | BC470M-S1(ERC) |
| C52A, B | .02 mfd. disc ceramic | 8E-17 | ID-203(CEN) |
| C53 | .05 mfd. 500V | 8E-29 | 36C142A(SPR) |
| CR1 thru CR... | 1N2069 diode | 16A-39 | 1N2069(TEX) |
| CR11 | Zener diode | 16A-21 | M26.2TS(IN) |
| CR12 | 1N54A germanium diode | 16A-11 | 1N54A(SYL) |
| CR13 | 1N54A germanium diode | 16A-11 | 1N54A(SYL) |
| CR14 | 1N54A germanium diode | 16A-11 | 1N54A(SYL) |
| CR15 | 1N1514 | 16A-44 | (IRC) |
| CR16 | Zener diode | 16A-21 | M26.2TS(IN) |
| F1 | 115 Vac. use 1 Amp. | 26B-5MS | (BUS) |
| F1 | 230 Vac. use 1/2 Amp. | 26B-29 | MDL 1/2(BUS) |
| I1 | Lamp assembly | 60A-31 | 249-7841H-1431(DIALCO) |
| J1A, B | 3 contact male connector | 10G3-34MX | (SAN) |
| J1Z | Open circuit jack | 10G2-22FX | 41(SWI) |
| J2A, B | 22 pin printed circuit conn. | 10B22-1FX | 143-022-01(AMP) |
| J3A, B | Miniature phone jack | 10G2-22FX | 41(SWI) |
| J4 | 18 pin printed ckt. conn. | 10B18-1FX | 143-018-01(AMP) |
| J5 | Miniature phone jack | 10G2-22FX | 41(SWI) |
| L1 | Toroidal (10MH) coil | 66B-131 | (TRI) |
| MOT-1 | Motor paper drive 50 cycle | 38B-54 | (SAN) |
| MOT-1 | Motor paper drive 60 cycle | 38B-37 | (SAN) |
| MOT-2 | Synchronous Motor 50 cycle | 38B-21A | (SAN) |
| MOT-2 | Synchronous Motor 60 cycle | 38B-21 | (SAN) |
| P1 | Plug and cord set | 10G3-33MW | (SAN) |
| Q1 | Selected 2N450 transistor | 16T-21A | (SAN) |
| Q2 | 2N1306 transistor | 16T-33 | (TEX) |
| Q3 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q4 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| Q5 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| Q6 | 2N1306 transistor | 16T-33 | 2N1306(TEX) |
| Q7 | 2N450 transistor | 16T-21 | 2N450(GE) |
| Q8 | 2N1306 transistor | 16T-33 | 2N1306(TEX) |
| Q9 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| *Q10 | J5000 transistor | 16T-37MP | (SAN) |
| *Q11 | J5000 transistor | 16T-37MP | (SAN) |
| Q12 | J5000 transistor | 16T-37 | (SAN) |
| Q13 | 2N1131 transistor | 16T-28 | SMU020(TEX) |
| *Q14 | 4 matched silicon ME242 | 16T-56MQA | (SAN) |
| *Q15 | 4 matched silicon ME242 | 16T-56MQA | (SAN) |
| *Q16 | 4 matched silicon ME242 | 16T-56MQA | (SAN) |
| *Q17 | 4 matched silicon ME242 | 16T-56MQA | (SAN) |
| Q18A, B | HSG1 Power transistor | 16T-9 | (SAN) |
| Q19A, B | HSG1 Power transistor | 16T-9 | (SAN) |
| Q20 | 2N3053 transistor | 16T-61 | 2N3053(RCA) |
| Q21 | J5000 transistor | 16T-37 | (SAN) |
| Q22 | 2N1038-1 transistor | 16T-38 | 2N1038-1(TEX) |
| Q23 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| Q24 | 2N3053 transistor | 16T-61 | 2N3053(RCA) |
| Q25 | 2N3053 transistor | 16T-61 | 2N3053(RCA) |
| Q26 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |

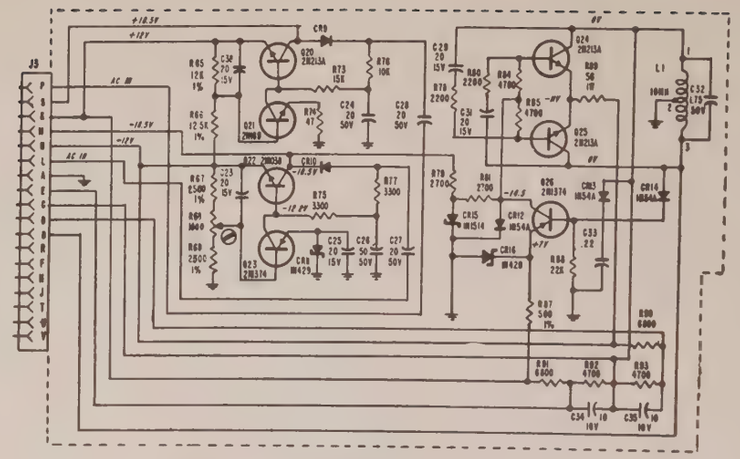
*The following transistors are matched: (Q10, Q11)(Q14, Q15)(Q16, Q17)

| | | | |
|---|---|---|---|
| R1 | 10K ± 1% 1/4 W | 50H-103G | N-11(WEL) |
| R2 | 3.9K ± 5% 1/2 W | 50AB-392J | EB(AB) |
| R3 | 37.5K ± 1% 1/4 W | 50H-375-2G | N-11(WEL) |
| R4 | 50K ± 1% 1/4 W | 50H-503G | N-11(WEL) |
| R5 | 4.7K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R6 | 50K ± 1% 1/4 W | 50H-503G | N-11(WEL) |
| R7 | 22K ± 5% 1/2 W | 50AB-223J | EB(AB) |
| R8 | 22K ± 5% 1/2 W | 50AB-223J | EB(AB) |
| R9 | 3.9K ± 5% 1/2 W | 50AB-392J | EB(AB) |
| R10 | 27K ± 5% 1/2 W | 50AB-273J | EB(AB) |
| R11 | 27K ± 5% 1/2 W | 50AB-273J | EB(AB) |
| R12 | 10K ± 1% 1/4 W | 50H-103G | N-11(WEL) |
| R13 | 18K ± 5% 1/2 W | 50AB-183J | EB(AB) |
| R15 | .5 meg ± 1% 1/4 W | 50H-504G | N-11(WEL) |
| R16 | .2 meg ± 1% 1/4 W | 50H-204G | N-11(WEL) |
| R17 | 12K ± 5% 1/2 W | 50AB-123J | EB(AB) |
| R18 | 47K ± 5% 1/2 W | 50AB-473J | EB(AB) |
| R19 | 50K ± 1% 1/4 W | 50H-503G | N-11(WEL) |
| R20 | 3K ± 1% 1/4 W | 50H-302G | N-11(WEL) |
| R21 | 3.9K ± 5% 1/2 W | 50AB-392J | EB(AB) |
| R22 | 150 ohm ± 5% 1/2 W | 50AB-151J | EB(AB) |
| R23 | 4.7 K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R24 | 10K ± 5% 1/2 W | 50AB-103J | EB(AB) |
| R25 | 150K ± 1% | 50H-154G | N-11(WEL) |
| R26 | 1K ± 1% 1/4 W | 50H-102G | N-11(WEL) |
| R27 | 2.5 ohm 1% WW | 54PA-60F | PW-50B(TEL) |
| R28 | 3.9K ± 5% 1/2 W | 50AB-392J | EB(AB) |
| R29 | 3.9K ± 5% 1/2 W | 50AB-392J | EB(AB) |
| R30 | 4.7K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R31 | 12.5K ± 1% 1/4 W | 50H-125-2G | N-11(WEL) |
| R32 | 1.5K ± 1% 1/4 W | 50H-152G | N-11(WEL) |
| R33 | 120 Ohm ± 5% 1/2 W | 50AB-121J | EB(AB) |
| R34 | 1.5K ± 1% 1/4 W | 50H-152G | N-11(WEL) |
| R35 | 12.5K ± 1% 1/4 W | 50H-125-2G | N-11(WEL) |
| R36 | 12.5 K ± 1% 1/4 W | 50H-125-2G | N-11(WEL) |
| R37 | 120 ohm ± 5% | 50AB-121J | EB(AB) |
| R38 | 5.6K ± 5% 1/2 W | 50AB-562J | EB(AB) |
| R39 | 12.5K ± 1% 1/4 W | 50H-125-2G | N-11(WEL) |
| R40 | 12.5K ± 1% 1/4 W | 50H-125-2G | N-11(WEL) |
| R41 | 1K ± 5% 1/2 W | 50AB-102J | EB(AB) |
| R42 | 680 ohm ± 5% 1/2 W | 50AB-681J | EB(AB) |
| R43 | 1.8 K ± 5% 1/2 W | 50AB-182J | EB(AB) |
| R44 | 120 ohm ± 5% 1/2 W | 50AB-121J | EB(AB) |
| R45 | 820 ohm ± 5% 1 W | 51D-821J | GB(AB) |
| R46A, B | .5 meg ± 1% 1/4 W | 50H-504G | N-11(WEL) |
| R47A, B | .27 meg 1% 1/4 W | 50H-274G | N-11(WEL) |
| R48A, B | 2050 ohm ± 1% 1/4 W | 50H-205-1G | N-11(WEL) |
| R49A, B | 10. 2K ± 1% 1/4 W | 50H-102-2G | N-11(WEL) |
| R50A, B | .5 meg ± 1% 1/4 W | 50H-504G | N-11(WEL) |
| R51A, B | 10K ± 1% 1/4 W | 50H-103G | N-11(WEL) |
| R52A, B | 15K gain pot. | 56A-125 | 47F-15K(CLA) |
| R53A, B | 23. 6 K ± 1% 1/4 W | 50H-236-2G | N-11(WEL) |
| R54A, B | 2.75K ± 1% 1/4 W | 50H-275-1G | N-11(WEL) |
| R55A, B | 3.47 K ± 1% 1/4 W | 50H-347-1G | N-11(WEL) |
| R56A, B | 10. 4 K ± 1% 1/4 W | 50H-104-2G | N-11(WEL) |
| R57A, B | 50K ± 1% 1/4 W | 50H-503G | N-11(WEL) |
| R58A, B | .1 meg ± 1% 1/4 W | 50H-104G | N-11(WEL) |
| R59A, B | 2.5K ± 1% 1/4 W | 50H-252G | N-11(WEL) |
| R60A, B | 250K position pot. | 56S-12 | Series 70(CHI) |
| R61A, B | 5K Pot. | 56A-144 | 45(CHI) |
| R62A, B | 7.5 ohm ± 5% 3 W | 53B-7R5J | 151E(SPR) |
| R63A, B | 7.5 ohm ± 5% 3 W | 53B-7R5J | 151E(SPR) |
| R64A, B | 200 ohm com. pot. | 56A-145 | 45(CTS) |
| R65 | 4K ± 1% 1/4 W | 50H-402G | N-11(WEL) |
| R66 | 4, 000 ohm ± 1% | 50H-402G | N-11(WEL) |
| R67 | 2.5 K ± 1% 1/4 W | 50H-252G | N-11(WEL) |
| R68 | 1K screwdriver adj. pot. | 56PA-1 | UPM-45(CHI) |
| R69 | 2K ± 1% 1/4 W | 50H-202G | N-11(WEL) |
| R70 | .5 ohm 12.5 W | 56R-4 | Model E(OHM) |
| R71 | .5 ohm 12.5 W | 56R-4 | Model E(OHM) |
| R73 | 15K ± 5% 1/2 W | 50AB-153J | EB(AB) |
| R74 | 82, 000 ohm ± 5% | 50AB-823J | EB(AB) |
| R75 | 1200 ohm ± 5% | 50AB-122J | EB(AB) |
| R76 | 10K ± 5% 1/2 W | 50AB-103J | EB(AB) |
| R77 | 1200 ohm ± 5% | 50AB-122J | EB(AB) |
| R78 | 2.2K ± 5% 1/2 W | 50AB-222J | EB(AB) |
| R79 | 8.2K ± 5% 1/2 W | 50AB-822J | EB(AB) |
| R80 | 2.2K ± 5% 1/2 W | 50AB-222J | EB(AB) |
| R81 | 220 ohm ± 5% 1/2 W | 50AB-221J | EB(AB) |
| R83A, B | 2.5 K ± 1% 1/4 W | 50H-252G | N-11(WEL) |
| R84 | 4.7 K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R85 | 4.7 K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R87 | 680 ohm ± 5% 1/2 W | 50AB-681J | EB(AB) |
| R88 | 6.8K ± 5% 1/2 W | 50AB-682J | EB(AB) |
| R89 | 22 ohm ± 5% 1 W | 51D-220J | GB(AB) |
| R90 | 6.8 K ± 5% 1/2 W | 50AB-682J | EB(AB) |
| R91 | 6.8K ± 5% 1/2 W | 50AB-682J | EB(AB) |
| R92 | 4.7K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R93 | 4.7K ± 5% 1/2 W | 50AB-472J | EB(AB) |
| R94A, B | 43.5 K ± 1% 1/4 W | 50H-435-2G | N-11(WEL) |
| S1A, B | 2 wafer, 7 pos. rotary | 62B-101 | (SAN) |
| S2A, B | 4 pos. 2 pole lever switch | 62N-12 | (SAN) |
| S3 | Push button speed switch | 62P-2 | (SAN) |
| S4 | Push button power switch | 62P-3 | (SAN) |
| S5 | SPDT switch | 62C-6 | 2CMD1-2AXX(ACR) |
| T1 | Output transformer | 66B-112MS | (SAN) |
| T2A, B | Modulation transformer | 66B-116MS | (SAN) |
| T3A, B | Input transformer | 66B-117 | (SAN) |
| T4 | Power transformer | 66B-80MS | (SAN) |
| T5 | Stylus heat transformer | 66B-115MS | (SAN) |

| VENDOR | ABBREVIATIONS | | |
|---|---|---|---|
| AB | Allen Bradley | HH | Hardwick Hindle |
| ACR | Acro | HOF | Hoffman |
| AMP | Amphenol | HP | Hewlett Packard |
| AST | Astron | IHC | Industrial Hardware Co. |
| BOD | Bodine | IR | International Rectifier Corp. |
| BUS | Bussman | IRC | International Resistance Co. |
| CBS | CBS Hytron | MAL | Mallory |
| CD | Cornell Dubilier | MIN | Minneapolis Honeywell |
| CEN | Centralab | NET | New England Transformer |
| CHI | Chicago Telephone | OAK | Oak |
| CLA | Clarostat | PH | Philco |
| CMS | Components Mfg. Service | PWC | Plastic Wire & Cable |
| DIALCO | Dialight Corporation | RWC | R. W. Cramer |
| ELC | Elco | SAN | Sanborn Company |
| EPC | Electron Products Co. | SPR | Sprague |
| ER | Erie | SPY | Sperry |
| ERC | Electrical Reactance Corp. | SWI | Switchcraft |
| FEN | Fenwal | SYL | Sylvania |
| GA | Good-All | TEL | Tel Labs |
| GE | General Electric | TEX | Texas Instrument |
| GRI | Grisby-Allison | TRI | Triad |
| | | WEL | Welwyn |

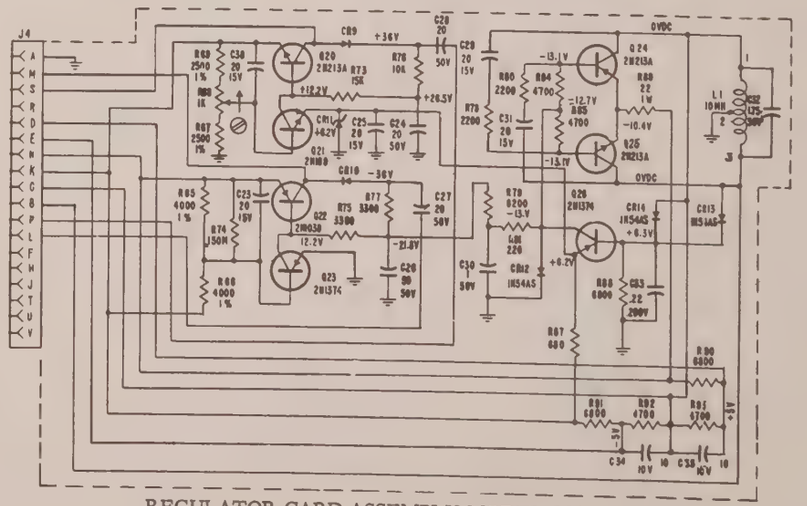
NOTES:

1. ALL SYMBOL NUMBERS WITH (A) OR (B) FOLLOWING INDICATES TWO COMPONENTS USED, IE (A) FOR CHANNEL "A", (B) FOR CHANNEL "B". SYMBOLS WITH NO LETTER IN PARENTHESIS INDICATES ONE COMPONENT USED & IS COMMON TO BOTH CHANNELS.
2. UNLESS OTHERWISE SPECIFIED ALL CAPACITOR VALUES ARE IN MICROFARADS & ALL RESISTORS ARE ± 5% 1/2 WATT.
3. UNLESS OTHERWISE SPECIFIED: ALL 1% RESISTORS ARE 1/4 WATT.
4. VOLTAGE MEASUREMENTS MADE WITH DC VTVM OF 100 MEGOHM INPUT IMPEDANCE & 3% F.S. ACCURACY.
5. Q1 IS SELECTED.
6. Q10 & Q11 ARE MATCHED.
7. Q14 TO Q17 ARE MATCHED.
8. LEADS CONNECTING MARKER STYLUS ELEMENT TO T5 ARE 27 WIRE WITH APPROXIMATELY .15 OHMS RESISTANCE.




REGULATOR CARD ASSEMBLY MODEL 320-100-C12

| SYMBOL | DESCRIPTION | SANBORN NO. | VENDOR CODE |
|---|---|---|---|
| CR9 | FA320A silicon rectifier | 16A-39 | FA320A(AUTO) |
| CR10 | FA320A silicon rectifier | 16A-39 | FA320A(AUTO) |
| CR11 | 1N4Z9 zener diode | 16A-21 | 1N4Z9(MOP) |
| CR12 | 1N54A germanium diode | 16A-11 | 1N54A(SYL) |
| CR13 | 1N54A germanium diode | 16A-11 | 1N54A(SYL) |
| CR14 | 1N54A germanium diode | 16A-11 | 1N54A(SYL) |
| CR15 | 1N1514 diode | 16A-44 | (IRC) |
| CR16 | 1N429 diode | 16A-21 | (MOP) |
| C28 | 20 mfd 15V | 8C-61 | TE1157(SPR) |
| C36 | 20 mfd 50V | 8C-66 | NLW341(CD) |
| C25 | 20 mfd 15V | 8C-61 | TE1157(SPR) |
| C26 | 50 mfd 50V | 8C-54 | 30D200(SPR) |
| C27 | 20 mfd 50V | 8C-66 | NLW341(CD) |
| C38 | 20 mfd 50V | 8C-66 | NLW341(CD) |
| C29 | 20 mfd 15V | 8C-61 | TE-1157(SPR) |
| C21 | 20 mfd 15V | 8C-61 | TE-1157(SPR) |
| C32 | 1.75 mfd 50V | 8B-116 | WMF(CD) |
| C33 | .22 mfd 200V | 8B-52 | Type 621(GA) |
| C34 | 10 mfd 10V | 8C-35 | NLW256(CD) |
| C35 | 10 mfd 10V | 8C-35 | NLW256(CD) |
| C39 | 20 mfd 15V | 8C-61 | TE-1157(SPR) |
| L1 | Toroidal transformer | 66C-5 | (SYL) |
| Q20 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q21 | 2N169 transistor | 16T-5 | 2N169(GE) |
| Q22 | 2N1038 transistor | 16T-25 | 2N1038(TEX) |
| Q23 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| Q24 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q25 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q26 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| R65 | 4K 1% 1/4 W | 50H-402G | N-11(WEL) |
| R66 | 13.3K ± 1% 1/4 W | 50H-133-2G | N-11(WEL) |
| R67 | 2.5K 1% 1/4 W | 50H-252G | N-11(WEL) |
| R68 | 1K screwdriver adj. pot. | 56PA-1 | UPM-45(CHI) |
| R69 | 2K ± 1% 1/4 W | 50H-202G | N-11(WEL) |
| R73 | 15K 5% 1/2 W | 50AB-153J | EB(AB) |
| R74 | .15 meg 5% 1/2 W | 50AB-154J | EB(AB) |
| R75 | 3.3K 5% 1/2 W | 50AB-332J | EB(AB) |
| R76 | 10K 5% 1/2 W | 50AB-103J | EB(AB) |
| R77 | 3.3K 5% 1/2 W | 50AB-332J | EB(AB) |
| R78 | 2.2K 5% 1/2 W | 50AB-222J | EB(AB) |
| R79 | 8.2K 5% 1/2 W | 50AB-822J | EB(AB) |
| R80 | 2.2K 5% 1/2 W | 50AB-222J | EB(AB) |
| R81 | 220 ohm 5% 1/2 W | 50AB-221J | EB(AB) |
| R84 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R85 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R87 | 680 ohm 5% 1/2 W | 50AB-681J | EB(AB) |
| R88 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R89 | 22 ohm 5% 1 W | 51D-220J | GB(AB) |
| R90 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R91 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R92 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R93 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| Q23 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| Q24 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q25 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q26 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| R65 | 4K 1% 1/4 W | 50H-402G | N-11(WEL) |
| R66 | 13.3K ± 1% 1/4 W | 50H-133-2G | N-11(WEL) |
| R67 | 2.5K 1% 1/4 W | 50H-252G | N-11(WEL) |
| R68 | 1K screwdriver adj. pot. | 56PA-1 | UPM-45(CHI) |
| R69 | 2K ± 1% 1/4 W | 50H-202G | N-11(WEL) |
| R73 | 15K 5% 1/2 W | 50AB-153J | EB(AB) |
| R74 | .15 meg 5% 1/2 W | 50AB-154J | EB(AB) |
| R75 | 3.3K 5% 1/2 W | 50AB-332J | EB(AB) |
| R76 | 10K 5% 1/2 W | 50AB-103J | EB(AB) |
| R77 | 3.3K 5% 1/2 W | 50AB-332J | EB(AB) |
| R78 | 2.2K 5% 1/2 W | 50AB-222J | EB(AB) |
| R79 | 8.2K 5% 1/2 W | 50AB-822J | EB(AB) |
| R80 | 2.2K 5% 1/2 W | 50AB-222J | EB(AB) |
| R81 | 220 ohm 5% 1/2 W | 50AB-221J | EB(AB) |
| R84 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R85 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R87 | 680 ohm 5% 1/2 W | 50AB-681J | EB(AB) |
| R88 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R89 | 22 ohm 5% 1 W | 51D-220J | GB(AB) |
| R90 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R91 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R92 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R93 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| Q23 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| Q24 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q25 | 2N213A transistor | 16T-26 | 2N213A(SYL) |
| Q26 | 2N1374 transistor | 16T-31 | 2N1374(TEX) |
| R65 | 4K 1% 1/4 W | 50H-402G | N-11(WEL) |
| R66 | 13.3K ± 1% 1/4 W | 50H-133-2G | N-11(WEL) |
| R67 | 2.5K 1% 1/4 W | 50H-252G | N-11(WEL) |
| R68 | 1K screwdriver adj. pot. | 56PA-1 | UPM-45(CHI) |
| R69 | 2K ± 1% 1/4 W | 50H-202G | N-11(WEL) |
| R73 | 15K 5% 1/2 W | 50AB-153J | EB(AB) |
| R74 | .15 meg 5% 1/2 W | 50AB-154J | EB(AB) |
| R75 | 3.3K 5% 1/2 W | 50AB-332J | EB(AB) |
| R76 | 10K 5% 1/2 W | 50AB-103J | EB(AB) |
| R77 | 3.3K 5% 1/2 W | 50AB-332J | EB(AB) |
| R78 | 2.2K 5% 1/2 W | 50AB-222J | EB(AB) |
| R79 | 8.2K 5% 1/2 W | 50AB-822J | EB(AB) |
| R80 | 2.2K 5% 1/2 W | 50AB-222J | EB(AB) |
| R81 | 220 ohm 5% 1/2 W | 50AB-221J | EB(AB) |
| R84 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R85 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R87 | 680 ohm 5% 1/2 W | 50AB-681J | EB(AB) |
| R88 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R89 | 22 ohm 5% 1 W | 51D-220J | GB(AB) |
| R90 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R91 | 6.8K 5% 1/2 W | 50AB-682J | EB(AB) |
| R92 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |
| R93 | 4.7K 5% 1/2 W | 50AB-472J | EB(AB) |




REGULATOR CARD ASSEMBLY MODEL 320-100-C24

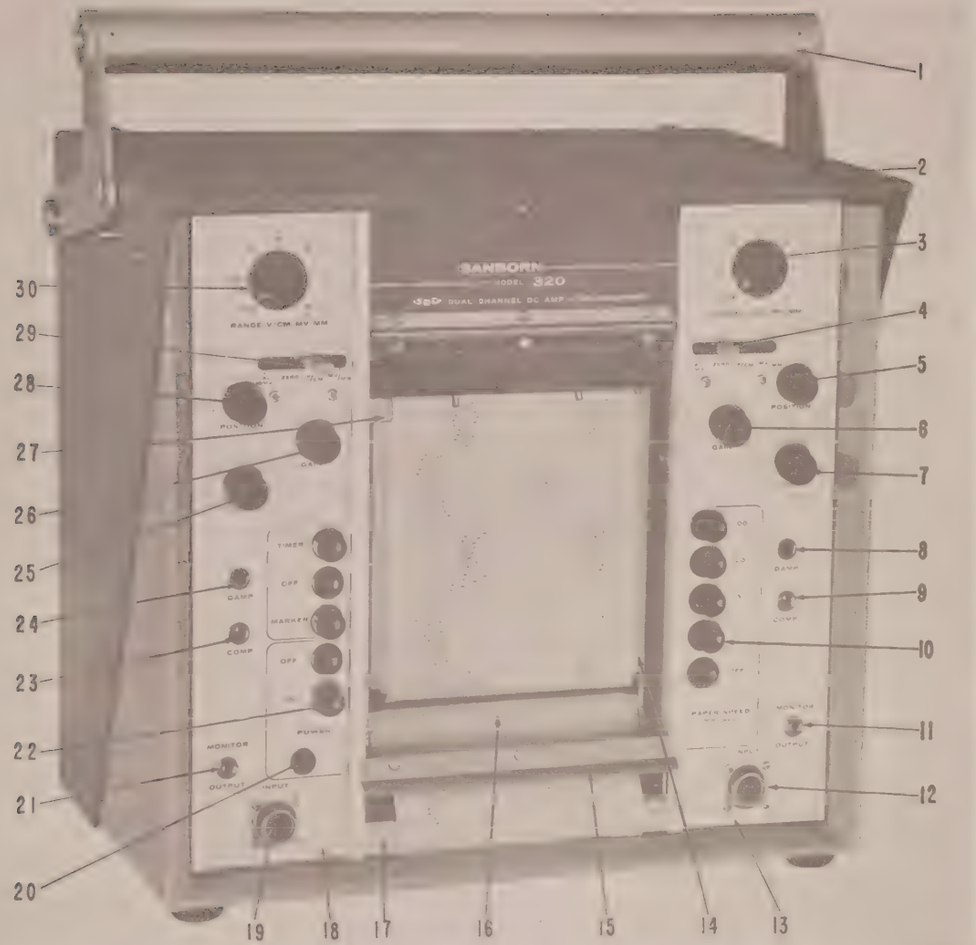



FIGURE 1. RECORDER MODEL 320, FRONT VIEW

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Handle Assembly (1) | 320-1400-C2 |
| | Handle (1) | 320-1404 |
| | Brackets (2) | 320-1408 |
| 2 | Carrying Case (1) | 320-1400 |
| | Carrying Case (inside) (1) | 320-1401 |
| | Carrying Case (outside)(1) | 320-1402 |
| | Latch Screw (2) | 154-190 |
| | Interlock Washer (2) | 73A-10 |
| | 10-32 Hex Nut (2) | |
| | 3/8 x 24 Hex Nut (2) | |
| | Retainer, Pin (2) | 320-1403 |
| | Retainer, Spring (2) | 320-1405 |
| | Pin, Handle Locking (2) | 320-1406 |
| | Screw, Handle (2) | 320-1407 |
| | Plug Buttons, 1/2" (2) | 22B-11 |
| | Plug Buttons, 3/8" (1) | 22B-2 |
| | Spring Coil (2) | 37G-5 |
| | Washer (Handle mounting)(2) | 74A-375A |
| | Washer (Handle mounting)(2) | 74A-500 |
| | Rubber Feet (4) | 77A-53 |
| | Rubber Feet (bottom) (4) | 77A-3 |
| | 3/16 x 6-32 Screw (2) | 80A-632-3C |
| | 1/2 x 6-32 Screw (4) | 80A-632-8E |
| | 1/2 x 1/4-20 Screw (4) | 80A-1420-8A |
| | 1/2 x 8-32 Sems (8) | 83A-8-8B |
| | 1/2 x 10-32 Sems (2) | 83A-10-8B |
| 3 | 7 Position Wafer Switch (See figure 4) | 62B-101 |
| 4 | Lever (S2B) Switch | 62N-12 |
| 5 | Pot 250K (R60B) | 56S-12 |
| 6 | Pot 15K (R52B) | 56A-125 |
| 7 | Pot .5 Ohm (R71) 12.5 W | 56R-4 |
| 8 | Pot 50 Ohm (R64B) | 56A-145 |
| 9 | Pot 5K (R61B) | 56A-144 |
| 10 | Switch, five button push button | 62P-2 |
| 11 | Phone Jack (J3B) | 10G2-22FX |
| 12 | 3 Contact Male Connector | 10G3-34MX |
| 13 | Panel, right control (1) | 320-106 |
| | Insert right front (1) | 320-104 |
| 14 | Table, paper drive assy. (See figure 15) | |
| 15 | Window Assembly | |
| | Window, Recorder (1) | 320-113 |
| | Cover, Slide (1) | 320-170 |
| | Handle, Window (1) | 320-171 |
| | Spring, Window (1) | 836-10 |
| | Holder Latch | 320-179 |
| | Hinge, Window (1) | 826-23 |
| | Latch, Viewing Window (2) | 300-107 |
| | Spring, Viewing Plate (2) | 300-115 |
| 16 | Guide, Paper (1) | 320-120 |
| 17 | Shield Pressure Roll (1) | 320-167 |
| 18 | Panel, Left Control (1) | 320-105 |
| | Insert, Left Panel (1) | 320-103 |
| 19 | 3 Contact Male Connector | 10G3-34MX |
| 20 | Lamp Assembly (I1) Power | 60A-31 |
| 21 | Phone Jack (J3A) | 10G2-22FX |
| 22 | 5 Button Push Switch (S4) | 62P-3 |
| 23 | Pot 5K (R61A) | 56A-144 |
| 24 | Pot 50 Ohm (R64A) | 56A-145 |
| 25 | Pot. .5 Ohm 12.5 W (R70) | 56R-4 |
| 26 | Pot 15K (R52A) | 56A-125 |
| 27 | Table Lock (1) | 320-174 |
| | Table Lock Spring (1) | 158-118 |
| 28 | Pot 250K (R60A) | 56S-12 |
| 29 | Switch Lever (S2A) | 62N-12 |
| 30 | 7 Position Wafer Switch (S1A) (See figure 4) | 62B-101 |

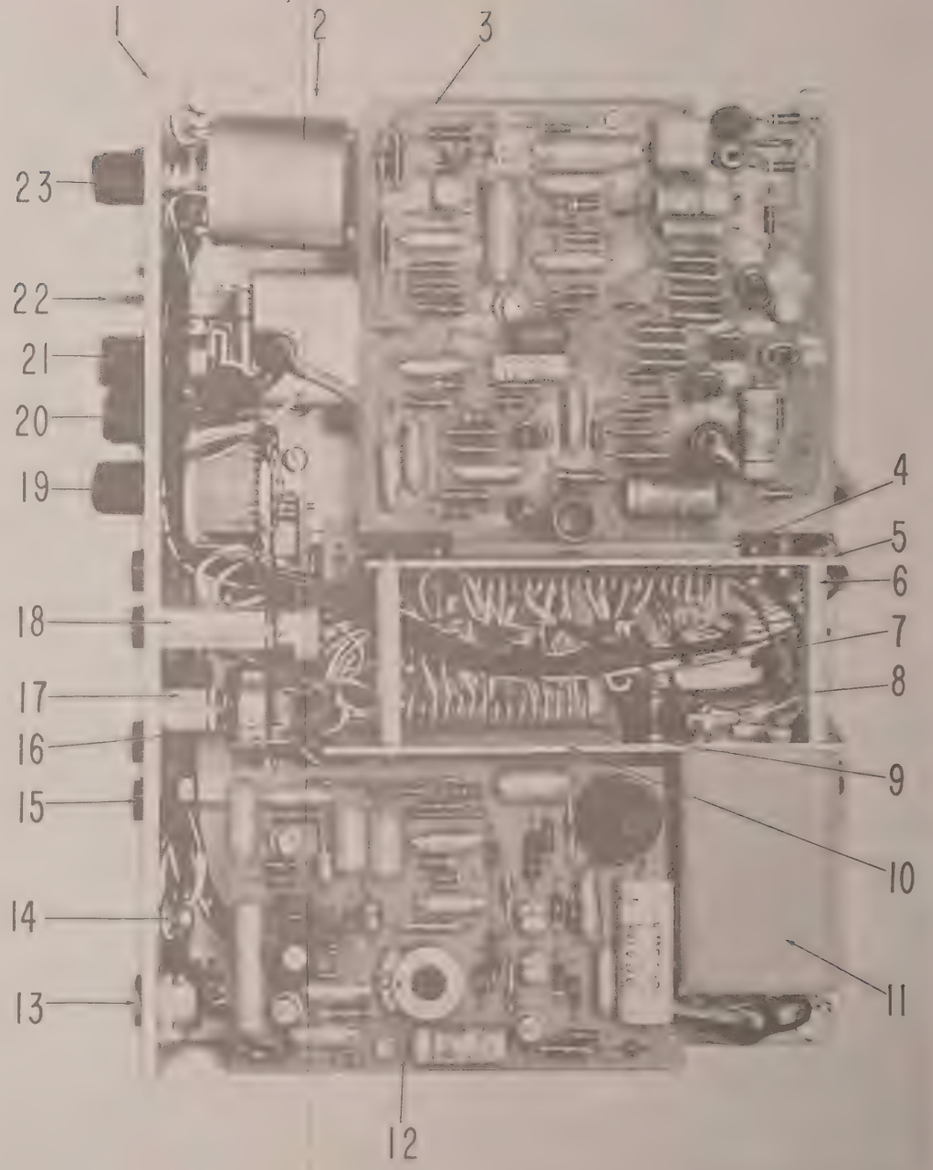



FIGURE 2. RECORDER, MODEL 320, RIGHT SIDE VIEW

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Panel, Right Control | 320-106 |
| 2 | Side Plate, Right | 320-108 |
| 3 | Printed Circuit Board Assy See Figure 21 | 950-3400 |
| 4 | 22 Pin Printed Circuit Conn. | 10B22-1FX |
| 5 | Chassis, Upper Right | 320-156 |
| | 3/8 x 4-40 Sems | 83A-4-6B |
| | Pem #4 | 40P-4-3 |
| | Eyelet | 20A-22 |
| 6 | Spacer, Hex (4) | 701-8T6-72 |
| | 3/8 x 6-32 Sems | 83A-6-6B |
| 7 | Res. .25 Ohm 10 W Deleted | 53A-R25K |
| 8 | Insulated Standoff (3) | 34E-1 |
| | 1/4 x 4-40 Sems | 83A-4-4B |
| 9 | 18 Pin Printed Ckt. Conn. (J4) | 10B18-1FX |
| 10 | Chassis, Lower Right | 320-157 |
| 11 | Transformer (T5) | 66B-115MS |
| | 6-32 Lockwasher | 73A-6 |
| | 6-32 Hex Nut | |
| | Lug, Right Angle | 34A-5A |
| 12 | Printed Circuit Board Assy. See figure 22 | 321-100-C10 |
| 13 | 3 Pin Male Conn. (J1B) | 10G3-34MX |
| | 3/8 x 4-40 Screw | 80A-440-6C |
| | Lockwasher #4 | 73A-4 |
| | Hex Nut #4 | |
| | Nylon Washer #4 | 710N-4 |
| | Lug, Right Angle | 34A-5 |
| 14 | Phone Jack (J3B) | 10G2-22FX |
| 15 | Switch, 5 Button Push (S3) | 62P-2 |
| | Bracket (1) | 320-117 |
| | Knob | 32A-52 |
| 16 | Capacitor .047, 200V (C36B) | 8B-58 |
| 17 | Pot 5K (R61B) Comp | 56A-144 |
| | Pot Standoff | 169-135P3 |
| | Bushing | 169-134 |
| | Lug Pot | 34A-8 |
| 18 | Pot 50 Ohm (R64B) | 56A-145 |
| | Pot Standoff | 169-135P4 |
| | Bushing | 169-134 |
| 19 | Pot .5 Ohm, 25 W (R71) | 56R-4 |
| | Lug, Pot | 34A-8 |
| | Knob 1/4 Shaft | 32A-47 |
| 20 | Pot 15K (R52B) Gain | 56A-125 |
| | Lug Pot | 34A-8 |
| | Knob 1/4 Shaft | 32A-47 |
| 21 | Pot 250K (R60B) Position | 56S-12 |
| | Knob 1/8 Shaft | 32A-53 |
| | Lug 1/4 Hole | 34A-31 |
| 22 | Rt. Cal. Assy. See Fig. 5 | 320-100-C10 |
| | Knob, Switch Lever | 32A-51 |
| | Washer, Nylon #4 | 710N-4 |
| | 3/8 x 4-40 Screw | 80A-440-6B |
| | See Figure 23 | |
| 23 | Swi. Assy. (S1B) (See figure 4) | 320-100-C3 |
| | Shield Can | 829-1P1 |
| | Knob, skirted | 32A-54 |

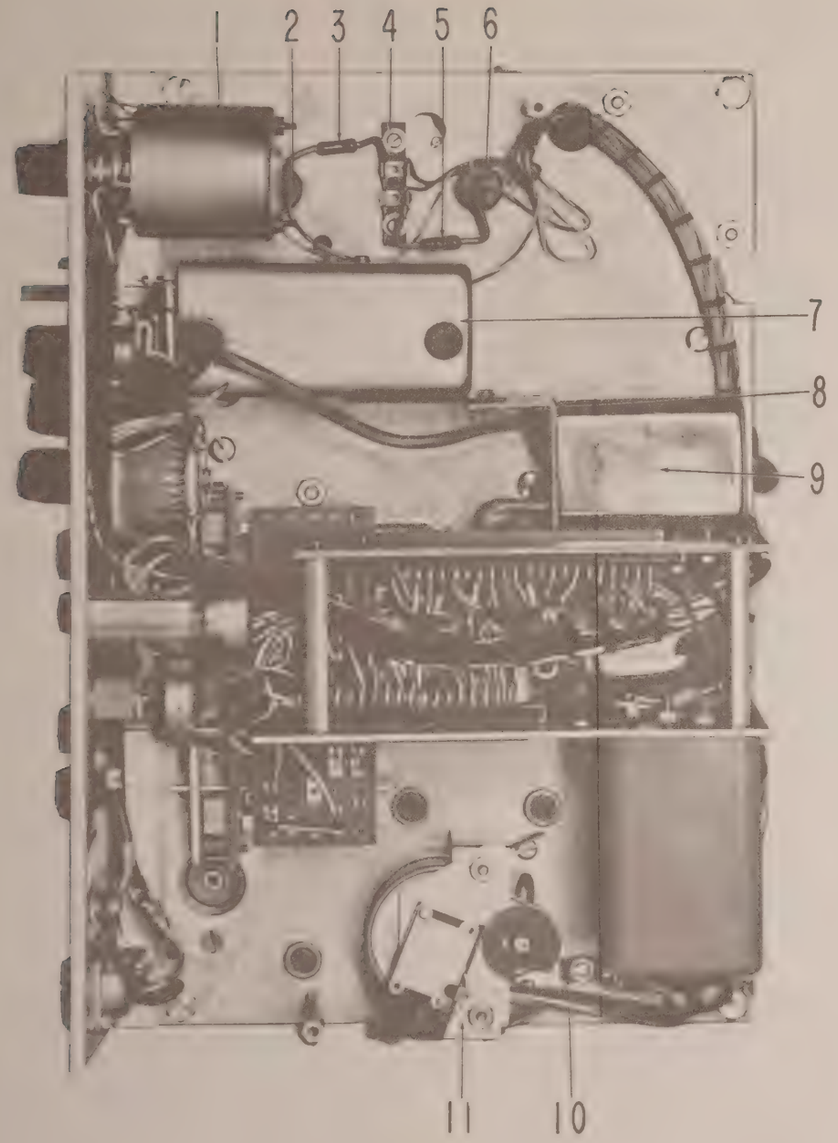



FIGURE 3. RECORDER, MODEL 320, RIGHT SIDE VIEW

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Shield Can | 829-1P1 |
| 2 | Trans. power H5G1 (Q18B) | 16T-9 |
| 3 | 7.5 Ohm ± 5% 3 W (R62B) | 53B-7R5J |
| 4 | 2 Contact Term. Strip (E2) | 64A-5 |
| 5 | 7.5 Ohm ± 5% 3 W (R62B) | 53B-7R5J |
| 6 | H5G1 Transistor (Q19B) | 16T-9 |
| 7 | Calibration Shield Can, Assy. | 320-100-C14 |
| 8 | Bracket, Transformer Mounting | 320-169 |
| | Pem #4 | 40P-4-2 |
| 9 | Transformer (J3B) Input | 66B-117 |
| | 6-32 Lockwasher | 73A-6 |
| | 6-32 Hex Nut | |
| 10 | Terminal Strip, 4 Con. (E1) | 64C-6 |
| 11 | Timer Assy 60 Cycle | 152-1300B-C2P5 |
| | Timer Assy 50 Cycle (See Figure 6) | 152-1300B-C2P6 |

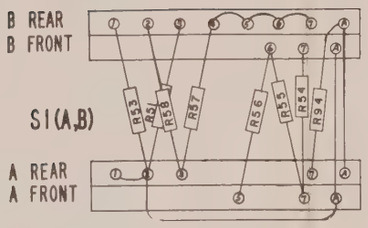



FIGURE 4. SWITCH ASSEMBLY
320-100-C3

| REFERENCE NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| S1 | Switch, 7 Position Wafer | 62B-101 |
| R54 | Resistor 2750 1/4W 1% | 50H-275-1G |
| R55 | Resistor 3470 1/4W 1% | 50H-347-1G |
| R56 | Resistor 10.4K 1/4W 1% | 50H-104-2G |
| R57 | Resistor 50K 1/4w 1% | 50H-503G |
| R58 | Resistor 100K 1/4W 1% | 50H-104G |
| R53 | Resistor 23.6K 1/4W 1% | 50H-236-2G |
| R51 | Resistor 10K 1/4W 1% | 50H-103G |
| R94 | Resistor 43.5K 1/4W 1% | 50H-435-2G |
| | Attenuator Shield Assy. | 320-100-C34 |

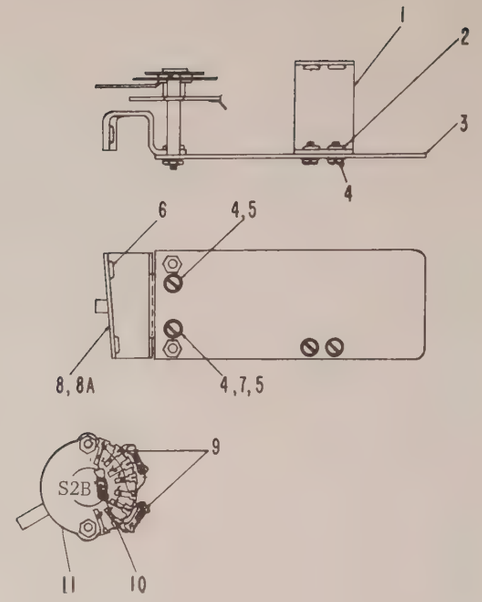



FIGURE 5. RIGHT CAL ASSEMBLY
320-100-C10

| REFERENCE NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1. | Bracket, cal. Assembly, Mounting | 320-150 |
| 2. | Pem No. 4-40 | 40P-4-2 |
| 3. | Printed Board Assy. See Fig. 23 | 320-100-C30 |
| 4. | Sems, No. 4-40 x 1/4 Long | 83A-4-4B |
| 5. | Hex Nut No. 4 | |
| 6. | Pem No. 4-40 | 40P-4-2 |
| 7. | Ground Lug Deleted | 34A-5 |
| 8. | Bracket, Right CAL Assembly Mounting | 320-152 |
| 8A. | Bracket, Left CAL Assembly Mounting | 320-151 |
| 9. | Resistor, 500K 1/4W 1% (R46B, R50B) | 50H-504G |
| 10. | Resistor, 10.2K 1/4W 1% (R49B) | 50H-102-2G |
| 11. | Switch, Lever (S2B) | 62N-12 |

NOTE: Left CAL Assembly, 320-100-C11, same except:
R49B becomes R49A
R46B becomes R46A
R50B becomes R50A
S2B becomes S2A

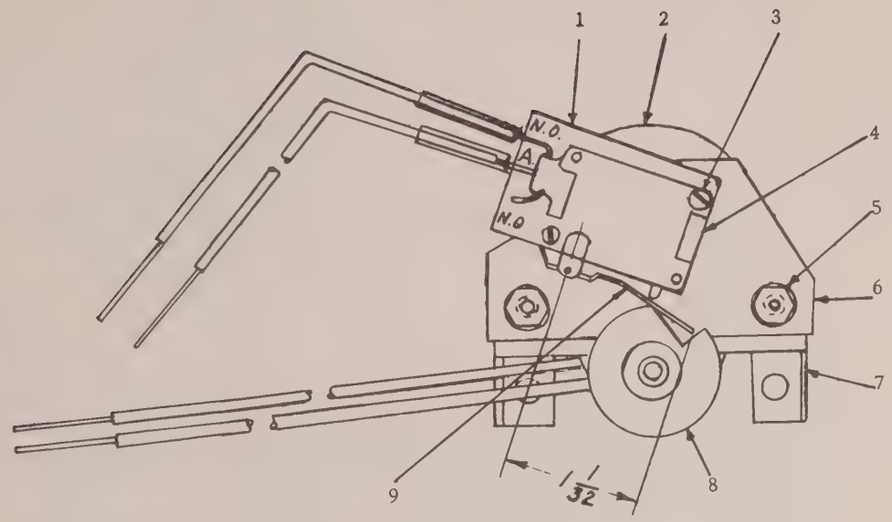



FIGURE 6. TIMER ASSEMBLY
60 CYCLE 152-1300B-C2P5
50 CYCLE 152-1300B-C2P6

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Power switch insulator | 572-148 |
| 2 | Synchronous motor (60 cycle) | 38B-21 |
| 3 | #2-56 x 7/16 lg. sems unit | 83A-2-7B |
| 4 | SPDT coin switch | 62C-6 |
| 5 | #6-32 x 1/2 lg. sems unit | 83A-6-8B |
| | #6-32 hex nut | |
| | Internal lock washer | 73A-6 |
| | Flat washer | 74A-6L |
| | #6-32 pems | 40P-6-2 |
| 6 | Timer switch plate | 152B-1303P1 |
| 7 | Timer mtg. bracket | 154B-1305P1 |
| 8 | Timer cam assembly | 152-1300B-C4 |
| 9 | Micro switch actuator | 62C-1A |

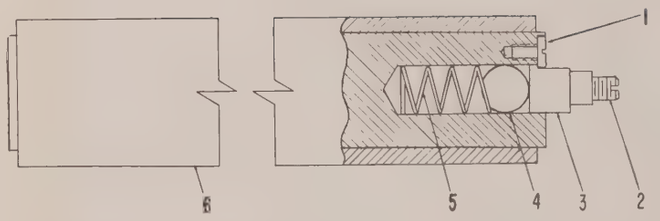



FIGURE 7. RECORDER BRAKE ROLL ASSEMBLY
320-100-C20

| REFERENCE NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1. | 4-40 x 3/16 Long Bnd. Hd. Sc. | 80A-440-3B |
| 2. | 1/2 Set Screw Sloted Cup Point | 81A-1032K |
| 3. | Pivot, Brake Adjustment | 320-138 |
| 4. | 3/8 Steel Ball | 6A-4 |
| 5. | Spring, Brake | 151-154 |
| 6. | Brake Roll Assembly | 151-100-C18P2 |

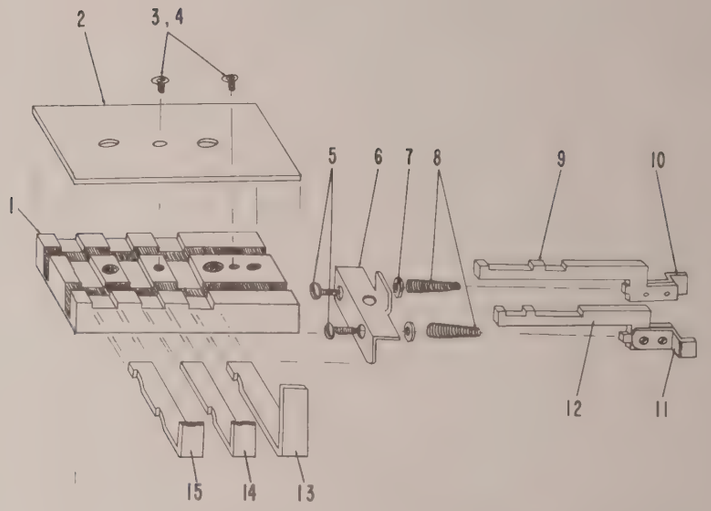



FIGURE 8. CLUTCH ACTUATOR ASSEMBLY 320-100-C27

| REFERENCE NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1. | Support, Clutch Actuator | 320-109 |
| 2. | Plate, Clutch Actuator Bearing | 320-123 |
| 3. | 4-40 x 5/16 Sems | 83A-4-5B |
| 4. | No. 4 Flat Washer | 74A-4 |
| 5. | 6-32 x 3/8 Sems | 83A-6-6B |
| 6. | Bracket, Actuator Spring | 320-163 |
| 7. | No. 6 Hex Nut | |
| 8. | Spring | 824-33 |
| 9. | Actuator, Clutch (lower) | 320-126 |
| 10. | Bracket, Actuator Adjust (lower) | 320-158 |
| 11. | Bracket, Actuator Adjust (upper) | 320-159 |
| 12. | Actuator, Clutch (upper) | 320-127 |
| 13. | Cam (5MM) | 320-130 |
| 14. | Cam (20MM) | 320-129 |
| 15. | Cam (100MM) | 320-128 |

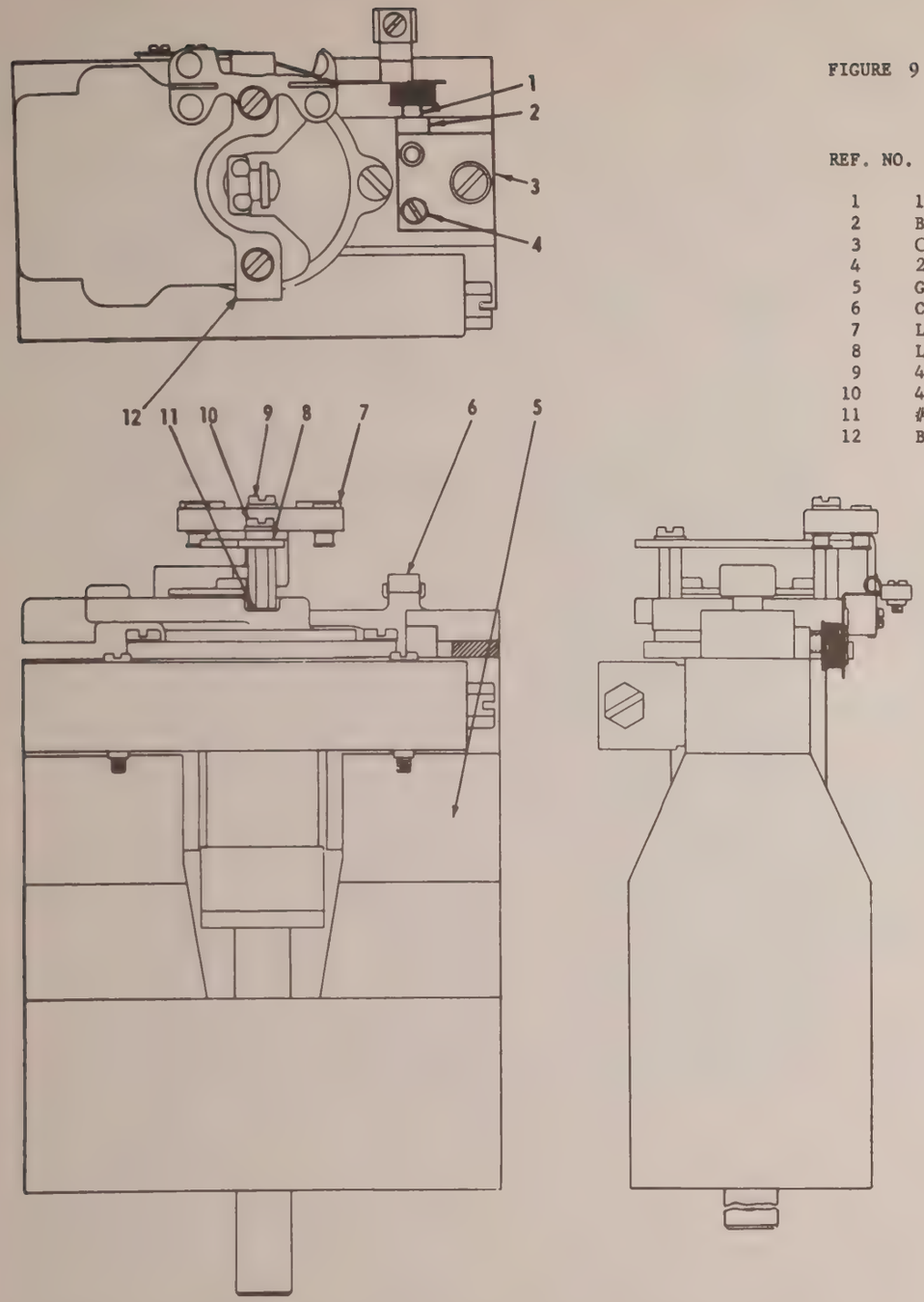



FIGURE 9. GALVANOMETER ASSEMBLY SANBORN NUMBER 608D

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | 10-32 x 1/2 long set scr. | 81D-10-8 |
| 2 | Block, adjust lead marker | 158-1033 |
| 3 | Clamp, L.M. Post | 608-108 |
| 4 | 2-56 x 1/4 sem | 83A-2-4B |
| 5 | Galvy assy. See Figure 10 | 607 |
| 6 | Coil & stylus holder assy. | 608D-100-C3 |
| 7 | Lead marker board assy. | 158-1000-C10 |
| 8 | Lead marker support | 608-102 |
| 9 | 4-40 x 7/16 sem | 83A-4-7B |
| 10 | 4-40 x 5/16 sem | 83A-4-5B |
| 11 | #4 int. lock washer | 73A-4 |
| 12 | Bridge | 608-103 |



FIGURE 9. GALVANOMETER ASSEMBLY SANBORN NUMBER 608D

FIGURE 10. GALVANOMETER ASSEMBLY SANBORN NUMBER 607

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | #4-40 sems x 5/16 long | 83A-4-5B |
| 2 | Shunt block | 158-1005 |
| 3 | Shunt step block | 158-1004 |
| 4 | #4-40 sems x 7/8 long | 83A-4-14B |
| 5 | Cover, shunt | 158-1007 |
| 6 | Assembly, shunt adjustment | 158-1000-C1 |
| 7 | Assembly, galvy (see figure 11) | 606 |
| 8 | Permanent magnet assembly | 151-1001 |
| 9 | Galvanometer Connector Cable | SQUARE 10G11-1MWL |

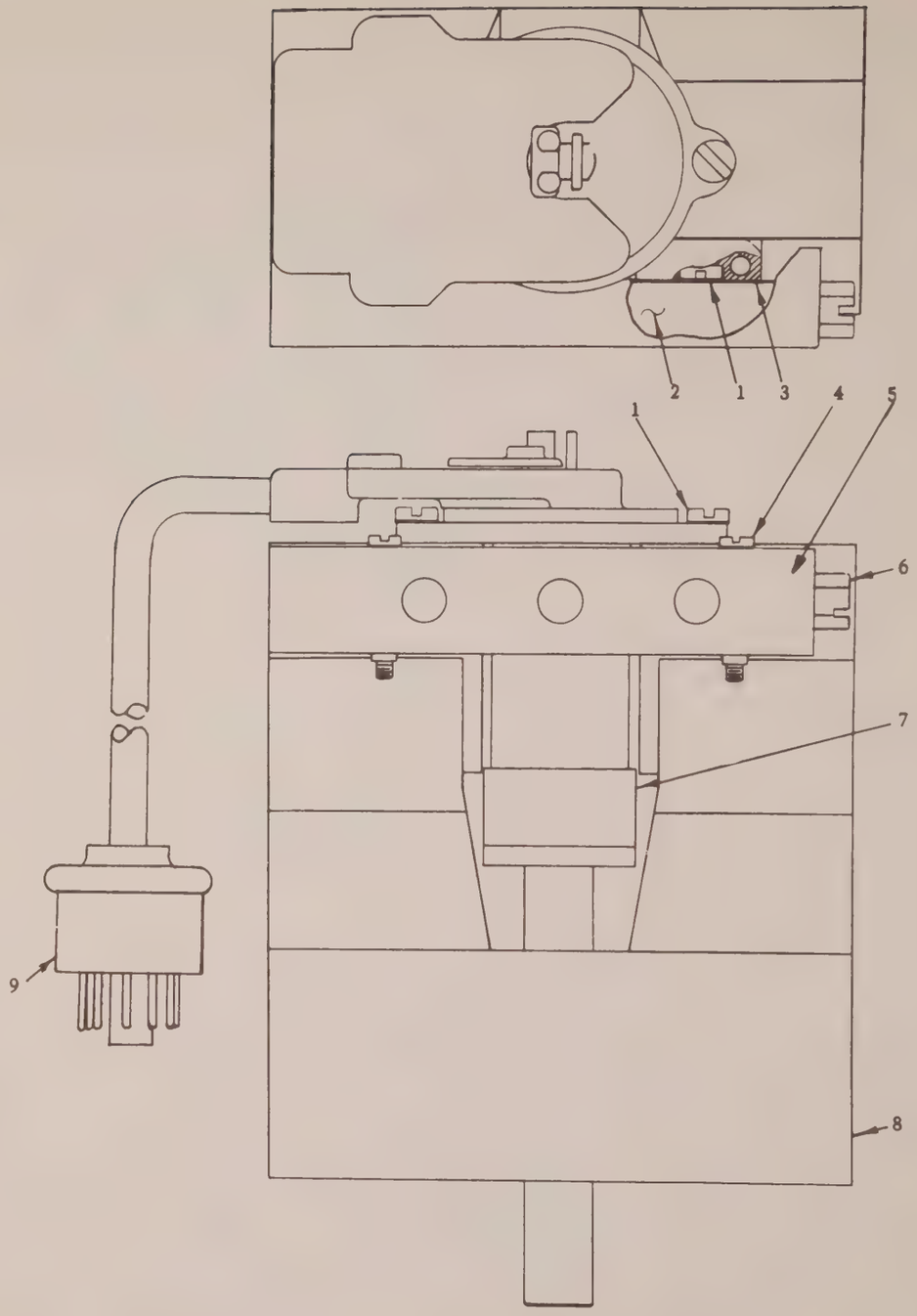
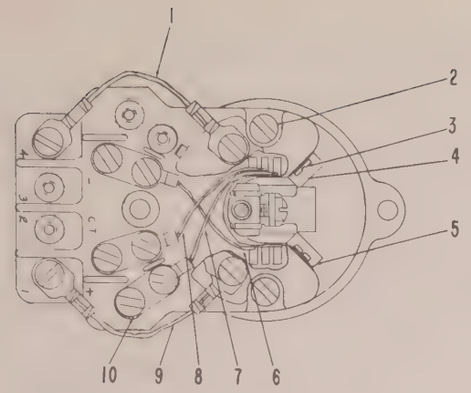
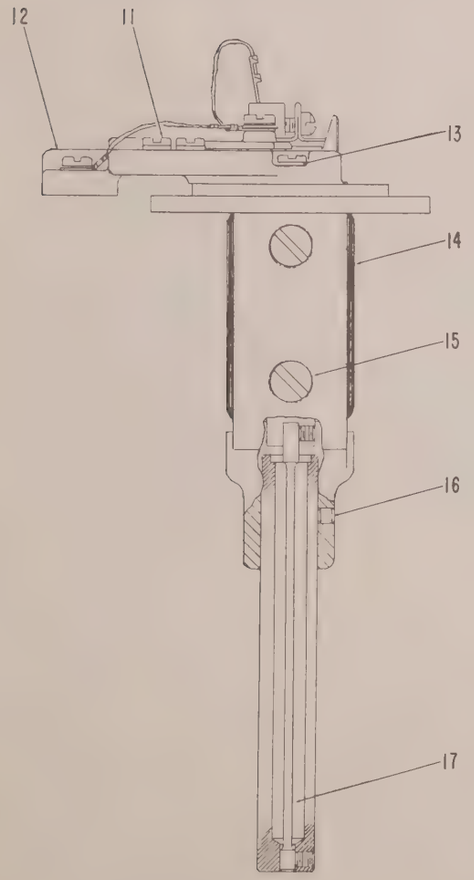



FIGURE 10. GALVANOMETER ASSEMBLY SANBORN NUMBER 607



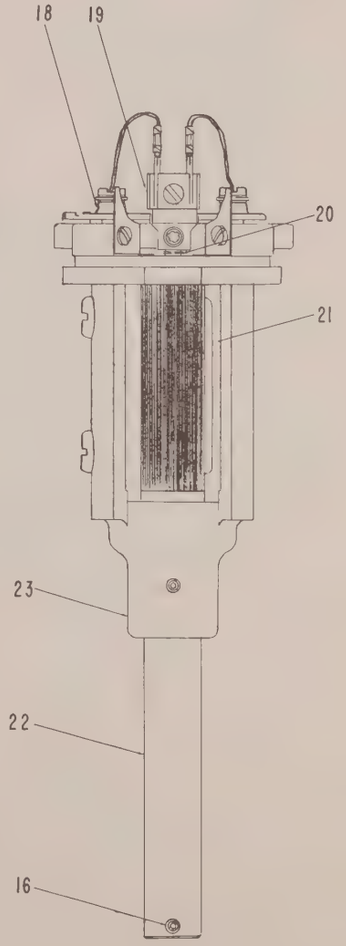
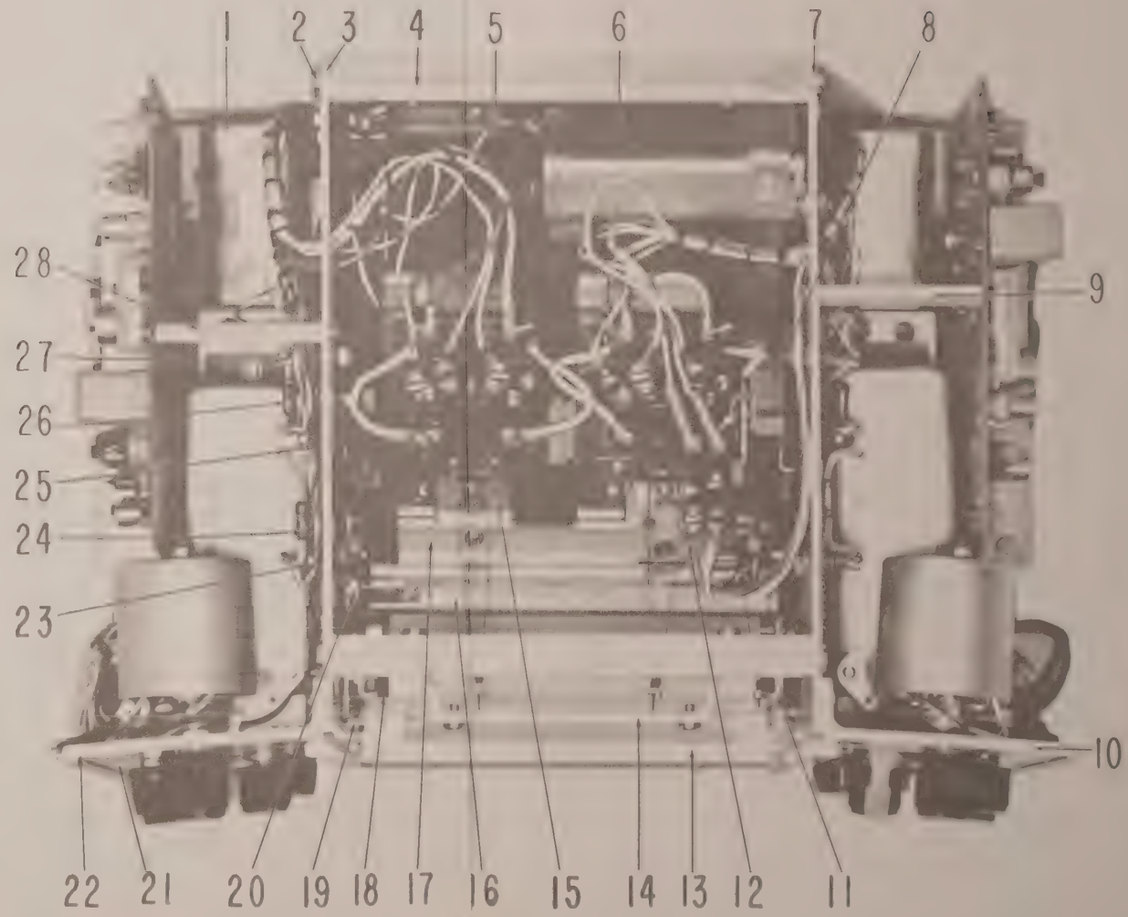




FIGURE 11 GALVANOMETER ASSEMBLY (INSERT) 606

| REFERENCE NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1. | Jumper | 606-100-C11-P1 |
| 2. | 4-40 x 7/16 Long Sem | 83A-4-7B |
| 3. | 2-56 x 1/8 Long Sem | 83A-2-2B |
| 4. | Stop | 613-106-P2 |
| 5. | Stop | 613-106-P1 |
| 6. | Pigtail and Lug Assembly | 606-100-C7-P3 |
| 7. | Pigtail and Lug Assembly | 606-100-C7-P1 |
| 8. | Pigtail and Lug Assembly | 606-100-C7-P2 |
| 9. | Jumper | 607-100-C11P2 |
| 10. | 4-40 x Long Machine Screw | 80A-440-4B |
| 11. | 4-40 x 1/4 Long Sem | 83A-4-4B |
| 12. | Galvy Cap Assembly | 606-106 |
| 13. | Plain Washer | 74A-4 |
| 14. | Galvy Coil Assembly | 606-100-C2 |
| 15. | 8-32 x 5/16 Long Sem | 83A-8-5B |
| 16. | 4-40 x 1/8 Long Allen Head S.S. Cup Point | 81B-4-2C |
| 17. | Torsion Rod | 606-116 |
| 18. | Galvy Cover | 606-109 |
| 19. | Stylus Mounting Adapter Assembly | 613-100-C7 |
| 20. | Grip ring | 59C-1 |
| 21. | Center Block | 572-330 |
| 22. | Sleeve Assembly | 621-100A-C4 |
| 23. | Galvy Coil Housing | 606-123 |

FIGURE 12. RECORDER, MODEL 320, TOP VIEW

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Transformer (T3A) | 66B-117 |
| | Chassis, Upper Left | 320-154 |
| | Bkt. Transformer Mounting | 320-169 |
| | 6-32 Lockwasher | 73A-6 |
| | 6-32 Hex Nut | |
| | Hex Nut #4 | |
| | 4-40 x 3/8 Sems | 83A-4-6B |
| | Pem #4 | 40P-4-3 |
| | Eyelet | 20A-22 |
| | Pem #4 | 40P-4-2 |
| 2 | Shoulder Screw #10 | 838-7 |
| 3 | Side Plate, Left | 320-107 |
| 4 | Spacer, Side Plate | 320-161 |
| 5 | Galvy Mounting Plate | 320-110 |
| 6 | Capacitor, 2.5 Mfd, 330V(C22) | 8B-117 |
| | 8-32 x 5/16 Sems | 83A-8-5B |
| | 8-32 Hex Nut | |
| 7 | Side Plate, Right | 320-108 |
| 8 | Clutch Actuator Assy. (See Figure 8) | 320-100-C27 |
| 9 | Spacer, Hex (2) | 701-8T6-68 |
| 10 | Panel, Right Control | 320-106 |
| | Insert, Right Panel | 320-104 |
| 11 | Paper Drive Table | 320-112 |
| 12 | Galvy With Lead Marker (See Figure 9) | |
| 13 | Shield, Pressure Roll | 320-167 |
| 14 | Spring Window | 836-10 |
| 15 | Galvy Assy. See Figure 10 | 607 |
| 16 | Hinge, Male | 320-118 |
| 17 | Hinge, Female | 320-119 |
| 18 | Platen | 320-164 |
| 19 | Table Lock | 320-121 |
| | Spring | 158-118 |
| | Stud, Table Lock | 320-141 |
| 20 | Stylus Lifter Assembly | |
| | Bracket Stylus Lifter | 320-144 |
| | Link, Stylus Lifter (lg. arm) | 320-143 |
| | Pivot, Stylus Lifter Link | 320-145 |
| 21 | Insert, Left Panel | 320-103 |
| 22 | Panel, Left Control | 320-105 |
| 23 | Trans, H5G1 (Q19A) | 16T-9 |
| 24 | 7.5 Ohm ± 5% 3 W (R63A) | 53B-7R5J |
| 25 | 2 Contact Terminal Strip (E3) | 64A-5 |
| 26 | 7.5 Ohm ± 5% 3 W (R62A) | 53B-7R5J |
| 27 | Trans. H5G1 (Q18A) | 16T-9 |
| 28 | Spacer, Hex | 701-8T6-68 |



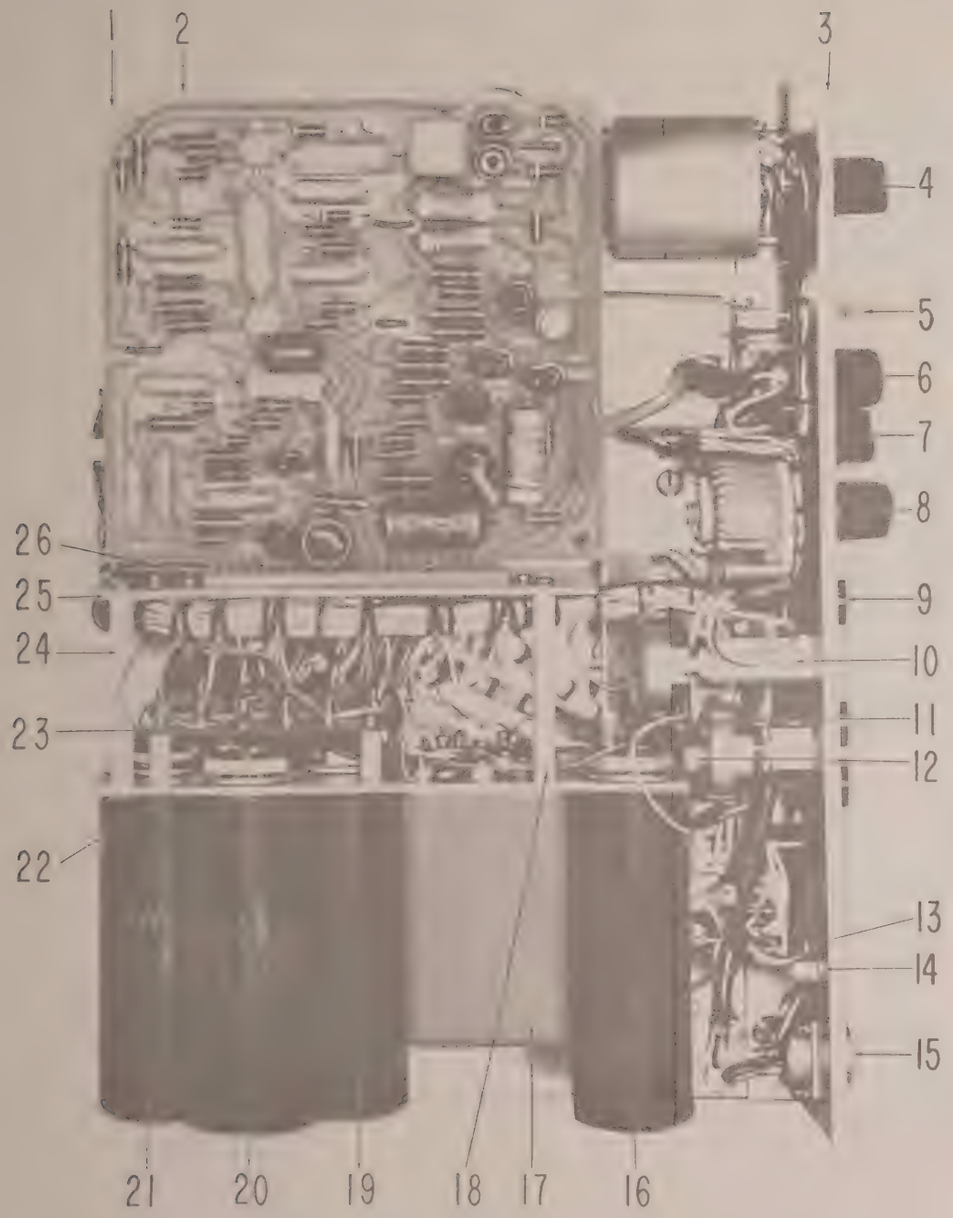



FIGURE 13. RECORDER, MODEL 320, LEFT SIDE VIEW

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Printed Circuit Board Assy. (See Figure 21) | 950-3400 |
| 2 | Side Plate, Left | 320-107 |
| 3 | Panel, Left Control | 320-105 |
| 4 | Switch Assy (S1A) (See Figure 4) | 320-100-C3 |
| | Shield Can | 829-1P1 |
| | Skirted Knob | 32A-54 |
| 5 | Right Calibration Assy. (S2A) (See figure 5) | 320-100-C10 |
| | Knob, Switch Lever | 32A-51 |
| | Washer, Nylon #4 | 710N-4 |
| | Screw, 3/8 x 4-40 | 80A-440-6B |
| | Calibration Card Assy. (See Figure 23) | 320-100-C30 |
| 6 | Pot 250K (R60A) | 56S-12 |
| | Knob, 1/8 Shaft | 32A-53 |
| | Lug, 1/4 Hole | 34A-31 |
| 7 | Pot 15K (R52A) Gain | 56A-125 |
| | Lug, Pot | 34A-8 |
| | Knob, 1/4 Shaft | 32A-47 |
| 8 | Pot .5 Ohm 12.5 W (R70) | 56R-4 |
| | Lug, Pot | 34A-8 |
| | Knob, 1/4 Shaft | 32A-47 |
| 9 | Push Switch 5 Button (S4) | 62P-3 |
| | .01 Mfd. Disc (C37) | 8E-6 |
| | Push Button Switch Bracket | 320-117 |
| | Knob, Push Switch | 32A-52 |
| 10 | Pot. 200 Ohm (R64A) | 56A-145 |
| | Pot Standoff | 169-135P4 |
| | Bushing | 169-134 |
| 11 | Pot, 5K (R61A) | 56A-144 |
| | Pot Standoff | 169-135P3 |
| | Bushing | 169-134 |
| | Lug, Pot | 34A-8 |
| 12 | .047, 200V Cap. (C36A) | 8B-S8 |
| 13 | Lamp Assembly (I1) | 60A-31 |
| 14 | Phone Jack, (J3A) | 10G2-22FX |
| 15 | 3 Pin Male Connector (J1A) | 10G3-34MX |
| | 3/8 x 4-40 Screw | 80A-440-6C |
| | Lockwasher #4 | 73A-4 |
| | Hex Nut #4 | |
| | Nylon Washer #4 | 710N-4 |
| | Lug, Right Angle | 34A-5 |
| 16 | 1900 Mfd, 25V Cap. (C21) | 8C-45MS |
| 17 | Transformer (T4) | 66B-80MS |
| | Lug, Right Angle | 34A-5A |
| 18 | Spacer | 701-8T6-72 |
| | 6-32 Lockwasher | 73A-6 |
| | 6-32 Hex Nut | |
| 19 | 1900 Mfd. 25 V (C19) | 8C-45MS |
| 20 | 1900 Mfd, 25 V (C20) | 8C-45MS |
| 21 | 1900 Mfd, 25 V (C18) | 8C-45MS |
| 22 | Bracket, Lower Left Side | 320-155 |
| 23 | Diode Mtg. Board Assy. (E4) (See figure 19) | 320-100-C2 |
| | 1/4 x 4-40 Sems | 83A-4-4B |
| 24 | Spacer | 701-8T6-72 |
| | 3/8 x 6-32 Sems | 83A-6-6B |
| 25 | Chassis, Upper Left Side | 320-154 |
| 26 | 22 Pin Printed Circuit (J2A) | 10B22-1FX |

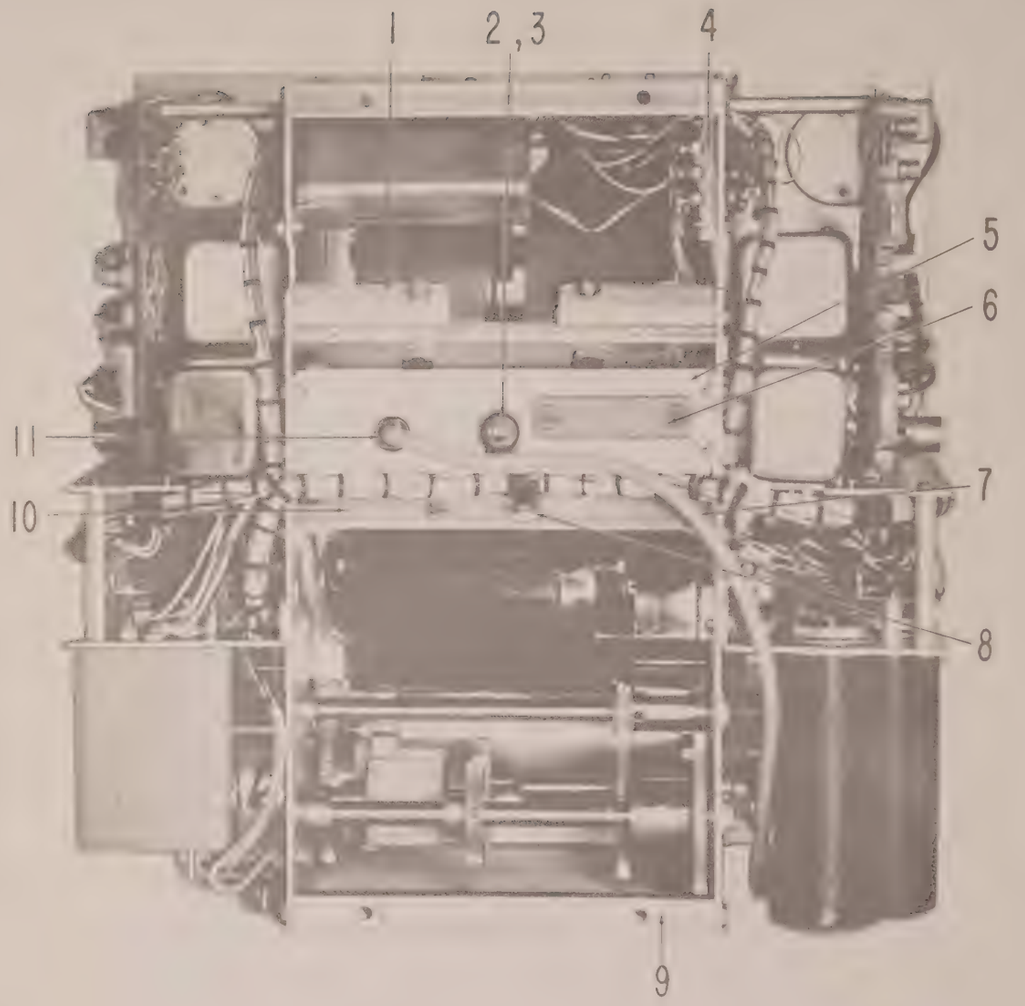
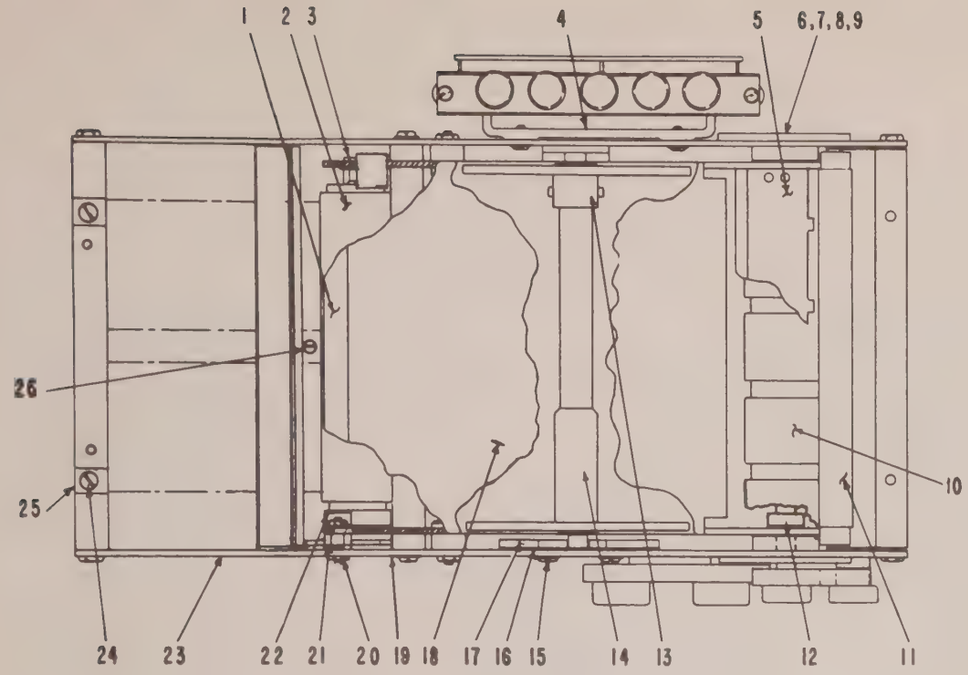
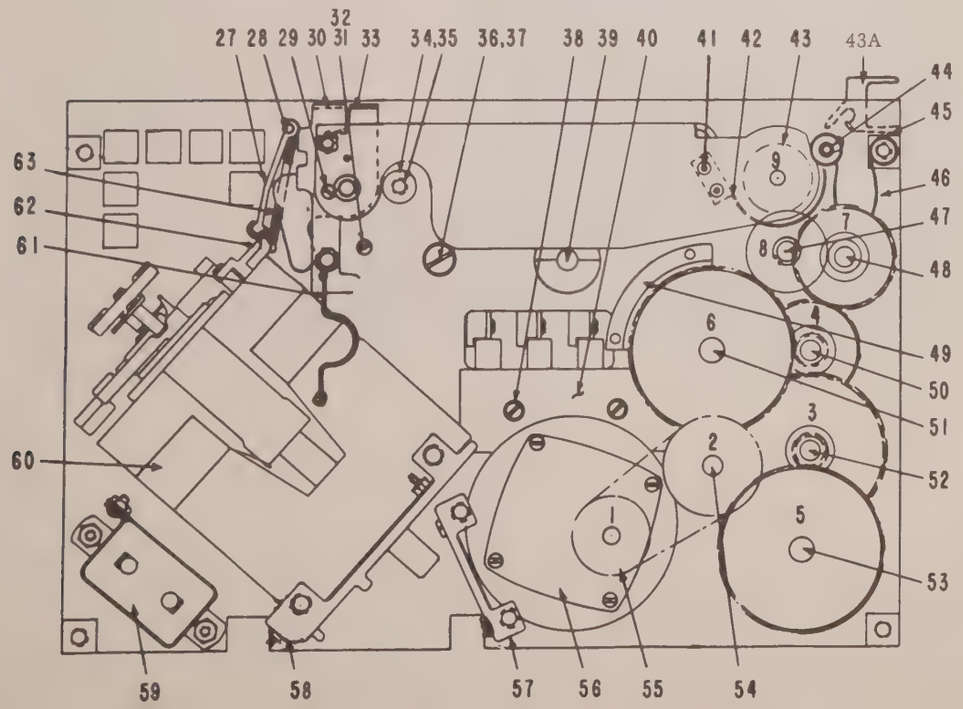
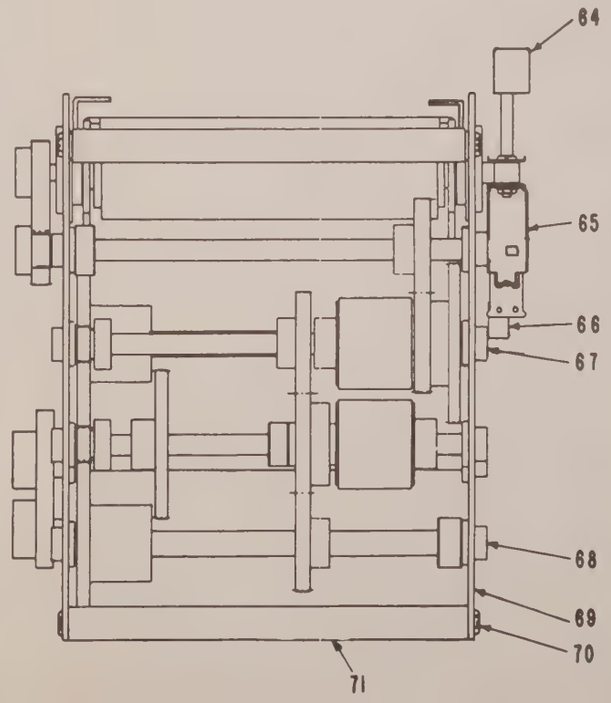



FIGURE 14. RECORDER, MODEL 320, BACK VIEW

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Galvy Mounting Plate | 320-110 |
| 2 | Fuse Holder | 26H-2MS |
| 3 | 1 Amp Slow Blow (F1) | 26B-5MS |
| 4 | 3 Contact Terminal Strip (E5) | 64B-5 |
| | 4-40 x 3/8 Sems | 83A-4-6B |
| 5 | Bracket, Fuse | 320-149 |
| | Pem #6 | 40P-6-2 |
| | Pem #2 | 40P-2-2 |
| | Sems 6-32 x 3/8 | 83A-6-6B |
| 6 | Nameplate | 320-102 |
| | Sems 2-56 x 3/16 | 83A-2-3B |
| 7 | Plug and Cord Set | 10C3-21MW |
| 8 | Cable Clamp | 12C-10 |
| | 6-32 x 3/8 Sems | 83A-6-6B |
| 9 | Side Plate Spacer | 320-161 |
| 10 | Motor Mounting Plate | 320-160 |
| 11 | Strain Relief Clamp | 12A-26 |




| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Platen | 320-164 |
| 2 | Brake Roll Assy. See fig. 7 | 320-100-C20 |
| 3 | Bearing Oilite (Flanged) | 5A-45 |
| 4 | Bracket, Switch Mounting | 320-117 |
| 5 | Paper Guide Assembly | 320-100-C28 |
| | Paper Guide | 320-120 |
| | Rivet | 47E-11 |
| | Spring Paper Guide | 863-9 |
| 6 | Retainer, Drive Roll Bearing | 320-125 |
| 7 | Retaining Ring | 59A-23 |
| 8 | Bearing (Ball) | 4S-4 |
| 9 | 8-32 FH, Mach. Screw | 80A-832-4D |
| 10 | Drive Roll Assembly | 320-100-C16 |
| 11 | Pressure Roll | 320-122 |
| 12 | Drive Roll Spacer | 703-16D-315-8 |
| 13 | Paper Spool Disc, Hub Assy and Spindle Assy. | 320-100-C22 |
| | Consists of: | |
| | Paper Spool Disc & Hub | 154-100-C8 |
| | Consists of: | |
| | Paper Spool Spindle | 320-116 |
| | Roll Pin | 44J-8-48 |
| 14 | Paper Spool Hub & Disc Assy | 154-100-C3 |
| 15 | 8-32 x 5/16 Sems | 83A-8-5B |
| 16 | Paper Supply Spring | 358-140 |
| 17 | Spindle Support (L.H.) | 320-148 |
| 18 | Paper Drive Table | 320-112 |
| 19 | Table Lock Stud | 320-141 |
| 20 | Shoulder Pivot Screw | 838-8 |
| 21 | 14 Washer (Used as Spacer) | 74A-14S |
| 22 | Pivot Assy. | 320-100-C21 |
| | Consists of: | |
| | Roll Pin | 44J-4-20 |
| | Shoe Brake | 151-159 |
| | Brake Roll Pivot | 320-139 |
| | Brake Shoe Housing | 320-140 |
| 23 | Upper Left Chassis | 320-100-C5 |
| 24 | 8-32 x 3/4 Sems | 83A-8-12B |
| 25 | Bracket | 801-118 |

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 26 | Table Latch Spring | 824-2 |
| 27 | Male Hinge | 320-177 |
| 28 | Rod | 825-2P4 |
| 29 | 1/8 6-32 Screw | 80N-632-2B |
| 30 | Table Lock & Striker Assy. | 320-100-C23 |
| | Consisting of: | |
| | Striker | 320-176 |
| | Table Lock | 320-174 |
| 31 | 6-32 x 5/16 Sems | 83A-6-5B |
| 32 | 8-32 Hex Nut | |
| 33 | Table Lift | 320-175 |
| 34 | Side Plate Spacer (Round) | 320-168 |
| 35 | 8-32 x 7/16 Sems | 83A-8-7B |
| 36 | Table Stop | 154-108 |
| 37 | 8-32 Nut (Hex) | |
| 38 | 6-32 x 3/4 Sems | 83A-6-12B |
| 39 | Support Spindle (RH) | 320-147 |
| 40 | Clutch Actuator Assy See figure 8 | 320-100-C27 |
| 41 | 4-40 x 3/16 Sems | 83A-4-3B |
| 42 | Guide Paper Drive Roll | 320-114 |
| | 4-40 x 3/16 Sems | 83A-4-3B |
| 43 | Gear 48T-48P | 5G-30 |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| 43A | Shield Pressure Roll | 320-167 |
| 44 | Bearing | 5A-28 |
| 45 | Side Plate Spacer | 320-162 |
| 46 | Pressure Roll Spring | 824-32 |
| 47 | Stud Shaft | 320-124 |
| | Ring Retainer | 59A-9 |
| | Washer Spacer | 710A-15 |
| | Gear 60T-48P | 5G-75 |
| | 10 Lockwasher Hex Nut | |
| 48 | #7 Shaft | 825-26 |
| | 24T-48P Gear | 5G-32 |
| | Spacing Washer | 710A-15 |
| | Collar | 827-5 |
| | 72T-48P Gear | 5G-33 |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| 49 | Cover Gear | 320-165 |
| | 6-32 x 3/16 Sems | 83A-6-3B |

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 50 | #4 Shaft | 825-23 |
| | Washer Spacing | 710A-15 |
| | 24T-48P Gear | 5G-32 |
| | 72T-48P Gear | 5G-33 |
| | Shaft Adapter | 358-704 |
| | Sleeve 8 Teeth | 358-705 |
| | Spring | 358-706 |
| | Clutch Hub Assembly | 320-100-C19 |
| | Consisting of: | |
| | Hub Assembly | 358-700-C12 |
| | Hub | 358-703 |
| | Bearing Oilite OD .43 ID .31 | |
| | Gear | 5G-36 |
| | 1/4 x 8-32 Lg. Screw Parkerized | |
| | Gear | 5G-74 |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| 51 | Shaft #6 | 825-25 |
| | Spacer Washer | 710A-2P4 |
| | 120T-48P Gear | 5G-34 |
| | Over Running Clutch | 5C-4 |
| | 24T-40P Gear | 5G-73 |
| | Spacer Washer | 710A-2P4 |
| | 8-32 x 7/8 Lg. Screw | 81A-832A |
| | 6-32 x 1/8 Lg. Screw | 81A-632A |
| 52 | Shaft #3 | 825-22 |
| | Spacing Washer | 710A-15 |
| | 24T-48P Gear | 5G-32 |
| | 180T-48P Gear (60 cycles) | 5G-72 |
| | 90T-42P Gear (50 cycles) | 5G-91 |
| | Collar | 827-5 |
| | Clutch Hub Assembly | 320-100-C18 |
| | Consisting of: | |
| | Hub Assembly | 358-700-C12 |
| | Hub | 358-703 |
| | Bearing Oilite OD .43 ID .31 | |
| | 1/4 x 8-32 Screw Parkerized | |
| | 48P-72T Gear | 5G-36 |
| | Spring | 358-706 |
| | Sleeve, 8 Teeth | 358-705 |
| | Shaft Adapter | 358-704 |
| | Spacer | 703-16D312-14 |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| 53 | Shaft #5 | 825-24 |
| | Washer Spacing | 710A-2P4 |
| | 120T-48P Gear | 5G-34 |
| | Over Running Clutch | 5C-4 |
| | 72T-48P Gear | 5G-35 |
| | Collar | 827-6 |
| | 6-32 x 1/8 Lg. Screw | 81A-632A |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| 54 | Shaft #2 | 825-21 |
| | Sprocket | 5S-6 |
| | Spacer (.906 Long) | 703-16D312-29 |
| | 36T-48P Gear (60 cycles) | 5G-71 |
| | 36T-42P Gear (50 cycles) | 5G-90 |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| 55 | Sprocket, 3/16 P-20T | 5S-7 |
| | 8-32 x 1/8 Lg. Screw | 81A-832A |
| | Chain Steel Drive | 5B-3 |
| 56 | Motor (Mot-1) 60 cycles | 38[illegible] 37 |
| | Motor (Mot-1) 50 cycles | 38[illegible]-54 |
| 57 | Motor Mounting Plate | 320-160 |
| | 8-32 x 7/16 Sems | 83A-8-7B |
| | 10-32 Slot Screw 1/2 Lg. | 81A-1032F |
| | 10-32 Slot Screw 3/8 Lg. | 81A-1032K |
| 58 | Galvy Mounting Plate | 320-110 |
| | 8-32 x 7/16 Sems | 83A-8-7B |
| 59 | Capacitor, 2.5 Mfd. 330V | 8B-117 |
| | 8-32 x 5/16 Sems | 83A-8-5B |
| | 8-32 Hex Nut | |
| 60 | Galvy Mounting Plate | 320-110 |
| | Galvy See Fig. 10 | 607 |
| | Galvy with Lead Marker (See figure 9) | 608D |
| 61 | Table Lock Spring | 158-118 |
| 62 | Hinge Female | 320-119 |
| 63 | Table Latch Spring | 824-2 |
| 64 | Push Switch Knob | 32A-52 |
| 65 | Switch (S3) | 62P 2 |
| 66 | Cam and Switch Clamp | 320-142 |
| 67 | Deleted | |
| 68 | Deleted | |
| 69 | Lower Right Chassis Assy. (See figure 25) | 320-100-C6 |
| 70 | #10 Shoulder Screw | 838-7 |
| 71 | Side Plate Spacer | 320-161 |

FIGURE 15. RECORDER ASSEMBLY

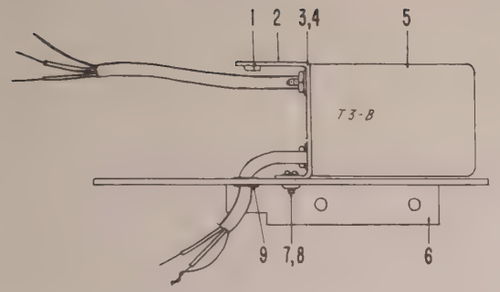



Figure 16. Upper Right Chassis Assembly 320—100—C7

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | #4 Pem | 40P-4-2 |
| 2 | Bracket, Transformer Mounting | 320-169 |
| 3 | 6-32 Lockwasher | 73A-6 |
| 4 | 6-32 Hex nut | |
| 5 | Transformer, T3B | 66B-117MS |
| 6 | Chassis, Upper Right side | 320-156 |
| 7 | 4-40 X 3/8 Sems | 83A-4-6B |
| 8 | #4 Pem | 40P-4-3 |
| 9 | Eyelet | 20A-22 |

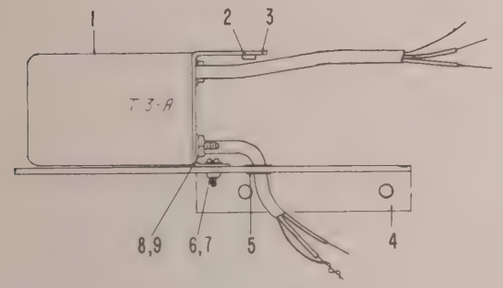
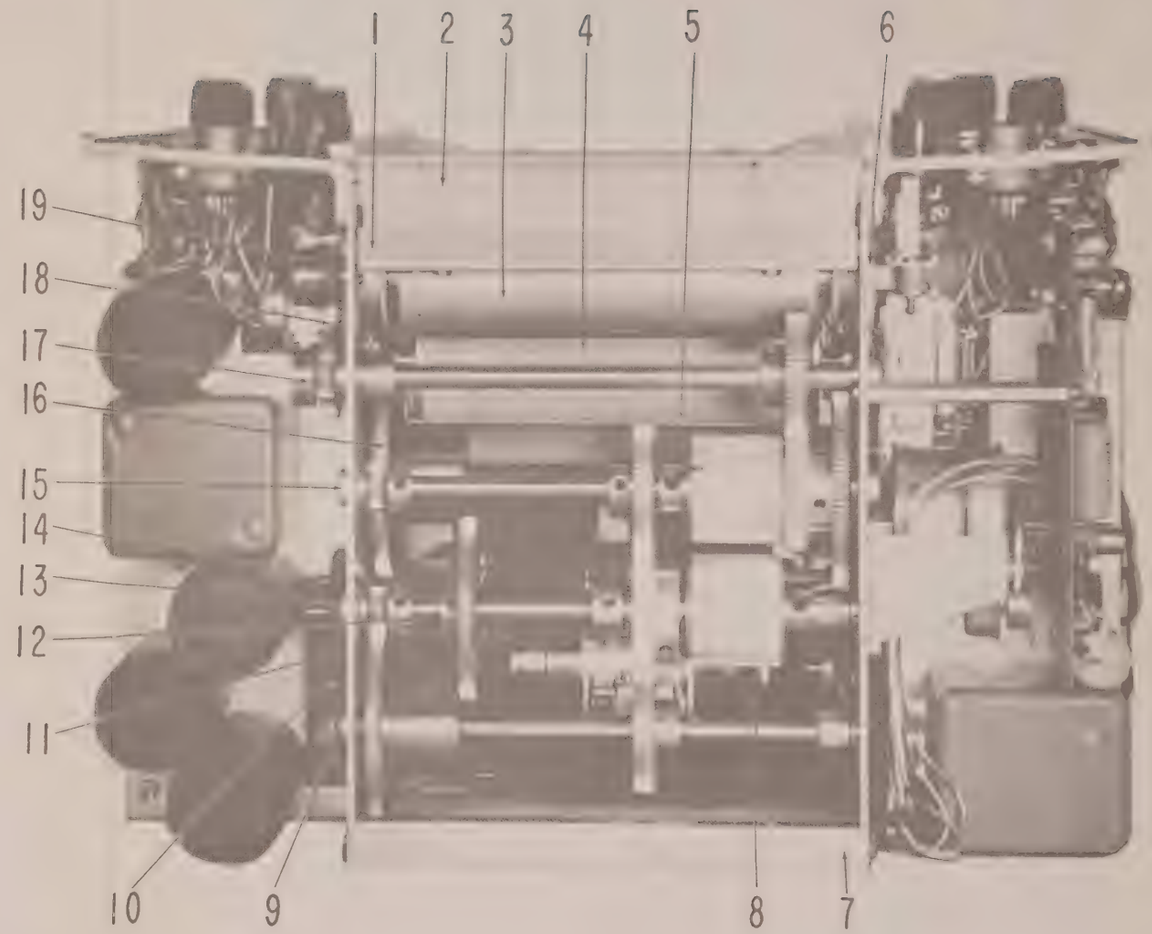



Figure 17. Upper Left Chassis Assembly

| REF. NO. | DESCRIPTION | SANBORN No. |
|---|---|---|
| 1 | Transformer, T3A | 66B-117MS |
| 2 | #4 Pem | 40P-4-2 |
| 3 | Bracket, Transformer mounting | 320-169 |
| 4 | Chassis, Upper Left side | 320-154 |
| 5 | Eyelet | 20A-22 |
| 6 | 4-40 X 3/8 Sems | 83A-4-6B |
| 7 | #4 Pem | 40P-4-3 |
| 8 | 6-32 Lockwasher | 73A-6 |
| 9 | 6-32 Hex nut | |

Figure 18. Sanborn Dual Channel DC Amplifier - Recorder Model 320, Bottom View

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Spacer, side plate | 320-162 |
| 2 | Spacer, square | 701-12T6-25 |
| 3 | Guide, paper drive roll | 320-114 |
| | 4-40 X 3/16 Sems | 83A-4-3B |
| 4 | Permapaper, Medical | 651-42 |
| | Permapaper, Industrial | 651-52 |
| 5 | Gear Cover | 320-165 |
| 6 | Retainer, drive bearing | 320-125 |
| 7 | Spacer, side plate | 320-161 |
| | No. 10 Shoulder screw | 838-7 |
| 8 | Motor, 50 cycle, 38B—54 — 60 cycle 38B—37 | |
| | Parts on shafts are called from left to right on figure | |
| 9 | Shaft No. 5 | 825-24 |
| | Spacer | 701-24D375-1 |
| | Gear with hub,120T-48P S.S | 5G-34 |
| | Overrunning miniclutch | 5C-4 |
| | Gear with hub, 72T-48P S.S. | 5G-35 |
| | Collar 3/8 I.D. | 827-6 |
| | 8-32 X 1/8 Lg. Allen hd. cup pt. screw | 81A-832A |
| | Washer, spacing | 710A-15 |
| 10 | Motor sprocket | 5S-6 |
| 11 | Drive chain, steel | 5B-3 |
| 12 | Shaft No. 2 (behind No. 3) | 825-21 |
| | Sprocket 25T-3/16 P | 5S-7 |
| | 8-32 X 1/8 lg. Allen hd. cup pt. screw | 81A-832A |
| | Spacer | 703-16D3-12-29 |
| | Gear 36T-48P-20° PA | 5G-71 |
| 13 | Shaft No. 3 | 825-22 |
| | Washer, spacing | 710A-15 |
| | Gear with hub, 24T-48 S.S. | 5G-32 |
| | 8-32 X 1/8 Lg. Allen hd cup pt. screw | 81A-832A |
| | Gear, 108T-48P 20°PA | 5G-72 |
| | 8-32 x 1/8 Lg. Allen hd. cup pt. screw | 81A-832A |
| | Collar | 827-5 |
| | Clutch hub assembly | 320-100-C18 |
| | Gear, 48P-72T | 5G-36 |
| | Hub assy | 358-700-C12 |
| | Hub, spring clutch | 358-703 |
| | Sleeve, clutch spring | 358-705 |
| | Spring, clutch | 358-706 |
| | Adaptor shaft | 358-704 |
| | 10-32 X 1/4 Allen hd cup pt | 81A-1032G |
| | Spacer | 703-16D312-14 |
| 14 | Sprocket | 5S-6 |
| | 8-32 X 1/4 Allen hd. cup pt. set screw | 81A-832A |
| 15 | Shaft No. 4 | 825-23 |
| | Gear with hub, 24T-48P S.S. | 5G-32 |
| | 8-32 X 1/8 Lg. Allen hd. cup pt. set screw | 81A-832A |
| | Gear with hub, 72T-48P | 5G-33 |
| | Clutch hub assembly | 320-100-C19 |
| | Hub assembly | 358-700-C12 |
| | Gear, 48P-72T | 5G-36 |
| | 8-32 X 1/4 Soc. hd. Set screw Parkerized | |
| | Gear, 96T-40P 20°PA | 5G-74 |
| | Washer, spacing | 710A-15 |
| 16 | Shaft No. 6 | 825-25 |
| | Gear with hub, 24T-48P S.S. | 5G-34 |
| | Overrunning Miniclutch | 5C-4 |
| | Gear, spur | 5G-73 |
| | 8-32 X 1/8 Lg. Allen hd., cup pt. set screw | 81A-832A |
| 17 | Shaft No. 7 | 825-26 |
| | Gear with hub, 24T-48P S.S. | 5G-32 |
| | 8-32 X 1/8 Lg. Allen hd., cup pt. set screw | 81A-832A |
| | Collar | 827-5 |
| | 8-32 X 1/8 Lg. Allen hd. cup pt. set screw | 81A-832A |
| | Gear with hub 72T-48P 20°PA | 5G-33 |
| | Washer, spacing | 710A-15 |
| 18 | Stud shaft | 320-124 |
| | Retainer ring, external 5/16 | 59A-9 |
| | 10-32 Hex nut | |
| | Gear, 60T-48P-20°PA | 5G-75 |
| 19 | Gear, 48T-48P-20°PA | 5G-30 |



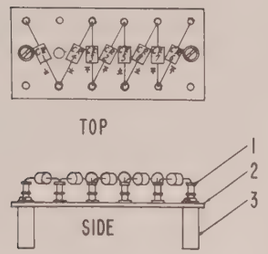



Figure 19. Diode Mounting Board Assembly (E4) 320-100-C2

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Turret Lugs | 34B-8 |
| 2 | Terminal Board | 750-4P6 |
| 3 | 4-40 X 1/4 Sems | 83A-4-4B |
| 4 | Spacer | 701-8T4-20B |
| CR1 thru CR8 | Rectifier 1N2069 | 16A-39 |

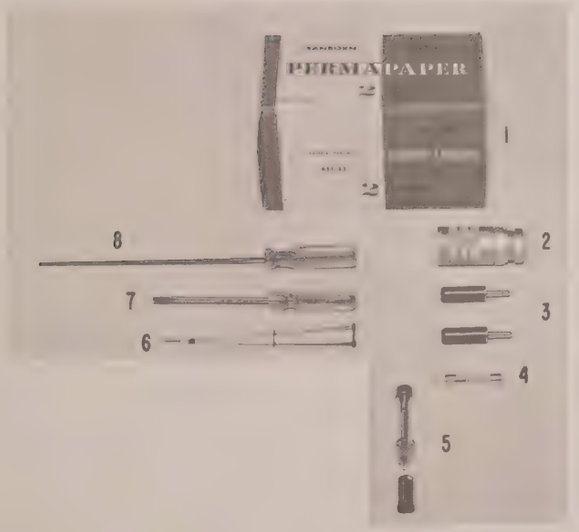



FIGURE 20. ACCESSORIES SUPPLIED WITH SANBORN RECORDER, MODEL 320

| ITEM | DESCRIPTION | AMT. | SANBORN NO. |
|---|---|---|---|
| 1 | Permapaper Industrial | 1 | 651-52 |
| | Permapaper Medical | 1 | 651-42 |
| 2 | *12 Contact Female Plug | 1 | 10A12-1FW |
| 3 | Plug, Miniature Phone | 2 | 10G2-22MW |
| 4 | Fuse, 1 Amp. Slow Blow | 1 | 26B-5MS |
| 5 | Stylus Pressure Tester | 1 | 442 |
| 6 | Writing Arm | 2 | 398 |
| 7 | Screwdriver (Stylus Pressure) | 1 | 37A-10A |
| 8 | Spline Wrench Assembly | 1 | 100-600-C5 |
| | *Changed to 3 Contact Female | 2 | 10G3-34FW |
| | 3 Wire Adapter | 1 | 10G3-11MFW |
| | Rubber Bushing | 2 | 77D-5 |

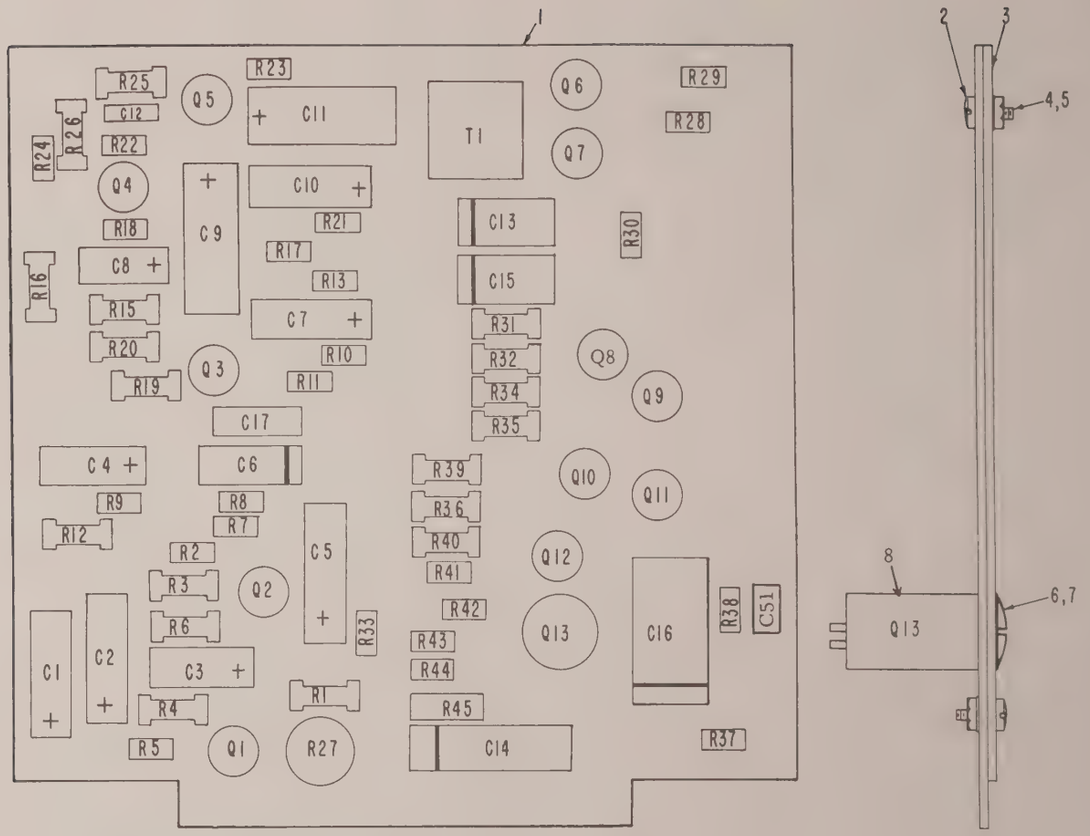



FIGURE 21. MEDIUM GAIN PREAMPLIFIER CARD, 950-3400

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Printed Board (machined) | 752-89 |
| 2 | 4-40 x 3/8 Screw | 80A-440-6B |
| 3 | Backing Strip and Shield | 950-3400-C3 |
| 4 | #4 Lockwasher | 73A-4 |
| 5 | #4 Hex Nut | |
| 6 | #8 Ext. Lockwasher | 72A-8 |
| 7 | 8-32 x 3/16 Screw | 80A-832-3B |
| 8 | Transistor Heat Sink | 16S-4 |

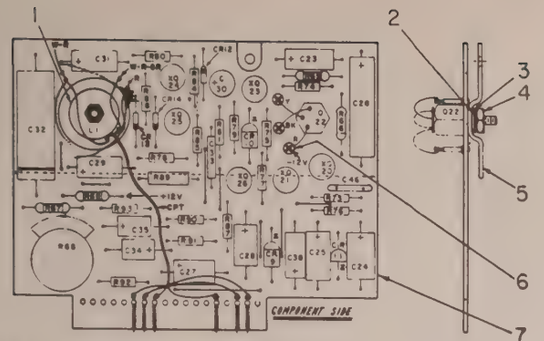



FIGURE 22. REGULATOR CARD 321-100-C10

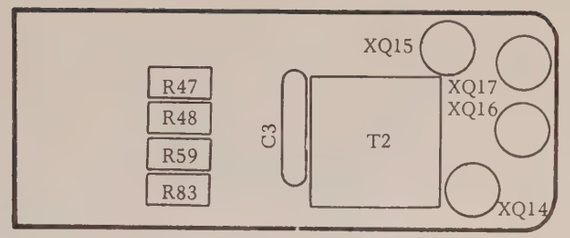



FIGURE 23. PRINTED CIRCUIT ASSEMBLY
320-100-C30

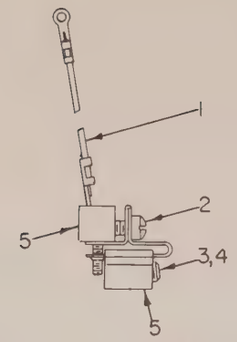



FIGURE 24. STYLUS MOUNTING ADAPTER
613-100-C7

| REF NO | DESCRIPTION | SANBORN NO |
|---|---|---|
| 1 | Hex Nut 4-40<br>Washer, Fiber<br>Lockwasher #4<br>Screw 4-40 x 3/4" Long | 74F-122<br>73A-4<br>80A-440-12B |
| 2 | Washer, Flat | 74A-108 |
| 3 | Lockwasher #10 | 74T-3 |
| 4 | Hex Nut 10-32 | |
| 5 | Heat Sink | 299-210 |
| 6 | Turret Lug (Long) | 34B-24 |
| 7 | Printed Board (Machined) | 752-143 |

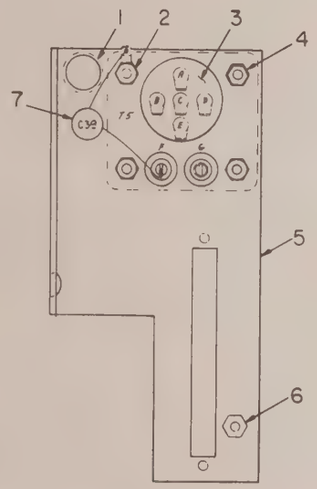



FIGURE 25. LOWER RIGHT CHASSIS ASSEMBLY
320-100-C6

| REF NO | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Eyelet | 20A-30 |
| 2 | Lug, Right Angle<br>Hex Nut 6-32<br>Lockwasher 6-32 | 34A-5A<br>73A-6 |
| 3 | Transformer | 66B-115MS |
| 4 | Spacer | 701-8T6-72 |
| 5 | Chassis, Lower Right Side | 320-157 |
| 6 | 3/8" 6-32 Sems<br>Spacer | 83A-6-6B<br>701-8T6-72 |
| 7 | Capacitor .01 MFD Disk | 8E-6 |

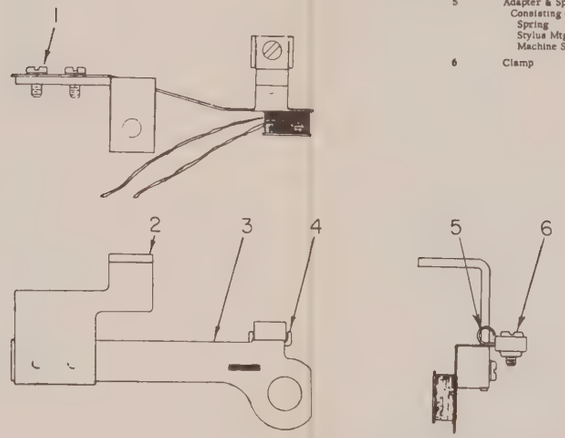



FIGURE 26. COIL AND STYLUS HOLDER ASSEMBLY 608D-100-C3

| REF NO | DESCRIPTION | SANBORN NO |
|---|---|---|
| 1 | #2-56 Sem x 3/16 Long | 83A-2-3B |
| 2 | Bracket, Coil Holder | 608-107 |
| 3 | Coil Assembly<br>Consisting of:<br>Black Wire x 5" Long<br>Lead Marker Coil Assembly<br>Consisting of:<br>1200 Turns #44 Wire Bobbin<br>Holder, Coil & Stylus | 608D-100-C4<br>W1C3-32-1<br>821-300-C3<br>20P-1<br>608-101-P1 |
| 4 | Shoe, Clamp | 158-1022 |
| 5 | Clamp, Lead Marker | 158-1023 |
| 6 | #2-56 Sem x 3/16 Long | 83A-2-3B |

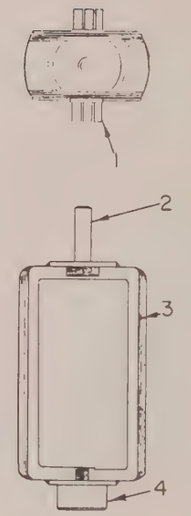



FIGURE 27.
GALVANOMETER COIL ASSEMBLY
606-100-C2

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Ass'y Galvy Coil Term., Insulation | 51-1505 |
| 2 | Pivot, Coil | 606-114 |
| 3 | Frame, Galvy Coil | 600-101 |
| 4 | Bracket, Coil (Lower) | 606-115 |

| REF. NO. | DESCRIPTION | SANBORN NO. |
|---|---|---|
| 1 | Pigtail Assy. | 613-100-C8 |
| 2 | #4-40 NC-3x 3/16 Lg. Fil. Hd. S.S. Sc. | 85B-4-3C |
| 3 | #8-32 x 3/16 Lg. Set Screw | 81B-832-3B |
| 4 | Shoe | 606-122 |
| 5 | Adapter & Spring Assy.<br>Consisting of:<br>Spring<br>Stylus Mtg. Adapter<br>Machine Screw 1/4 x 1/72 Fil. Hd. | 613-100-C6<br>613-110<br>613-107<br>85B-172-4C |
| 6 | Clamp | 613-108 |

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Tel. 25-87-36, 14-82-71

**NICARAGUA**
Roberto Terán G.
Edificio Terán
Apartado Postal 689
Managua
Tel. 3451, 3452
Cable ROTERAN

**PANAMA**
Electronico Balboa, S.A.
P.O. Box 4929
Panama City
Tel. 3-0833
Cable ELECTRON

**PERU**
H. W. Kessel S.A.
Av Corpac 312
San Isidro, Lima
Tel. 23900
Cable KESSEL

**PUERTO RICO**
San Juan Electronics Biophysical Inc.
Ponce de León No. 150, Stop 3
Pta. de Tierra Sta.
San Juan
Tel. (809) 725-3342

**URUGUAY**
Pablo Ferrando
S.A. Commercial e Industrial
Sarandi, 675
Casilla de Correo 370
Montevideo
Tel. 89631
Cable RADIUM

**VENEZUELA**
Citec, C.A.
Edif. Arisan—Of. No. 4
Avda. Francisco de Miranda
Chacaito
Apartado del Este 10.837
Caracas
Tel. 71.88.05
Cable CITECAL

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**In countries not listed, please contact:**
Hewlett-Packard Company
Export Marketing
1501 Page Mill Road
Palo Alto, California
Tel. (415) 326-7000
Cable HEWPACK

**AUSTRALIA**
Watson Victor Ltd.
Watson House
9-13 Bligh Street
Sydney, New South Wales
Tel. 28-2851
Cable WATSONVICTOR Sydney

Branch Offices:
Watson Victor Ltd.
Watson House
201 Victoria Parade
Collingwood, Victoria
Tel. 414116

Watson Victor Ltd.
Watson House
228 North Terrace
Adelaide, South Australia

Watson Victor Ltd.
Watson House
1122 Hay Street
West Perth, West Australia

Watson Victor Ltd.
Watson House
Box 117 P.O. Woollongabba
893 Stanley Street
East Brisbane, Queensland
Tel. 91-4441

Watson Victor Ltd.
Central Service Division
17 Vincent Street
Marrickville, N.S.W.

**INDIA**
The Scientific Instrument Co., Ld.
6, Tej Bahadur Sapru Road
Allahabad 1
Tel. 2451
Cable SICO Allahabad

Branch Offices:
The Scientific Instrument Co., Ld.
240, Dr. Dadabhai Naoroji Road
Bombay 1
Tel. 26-2642
Cable SICO Bombay

The Scientific Instrument Co., Ld.
11, Esplanade East
Calcutta 1
Tel. 23-4129
Cable SICO Calcutta

The Scientific Instrument Co., Ld.
30, Mount Road
Madras 2
Tel. 86339
Cable SICO Madras

The Scientific Instrument Co., Ld.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel. 271053
Cable SICO New Delhi

**IRAN**
Telecom, Ltd.
P.O. Box 1812
Teheran
Tel. 43850, 48111
Cable BASCOM Teheran

**ISRAEL**
Electronics & Engineering
Division of Motorola Israel Ltd.
16, Kremenetski Street
Tel-Aviv
Tel 35021
Cable BASTEL Tel-Aviv

**JAPAN**
Heiwa Bussan Co., Ltd.
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Chiyoda-ku, Tokyo
Tel. (211) 8456
Cable KISHMAKER Tokyo

**KENYA**
International Aeradio
(East Africa), Ltd.
Nairobi Airport
P.O. Box 19012
Embakasi
Tel. 82222
Cable INTAERIO Embakasi

**KOREA**
Asia Science & Company
International P.O. Box 1250
28, 1-KA Choongmoo-ro
Choong-ku, Seoul
Tel. 2-1860
Cable ASIASCIENC Seoul

**LEBANON**
F. Makhlouf & Co.
144 Damascus Avenue
Beirut
Tel. 26221-42662
Cable MAKHLOUFCO Beirut

**MALAYSIA**
Sharikat Mecomb (M)
Sendirian Berhad
No. 6, Jalan 69D, Petaling Jaya
Selangor
Tel. 59570
Cable MECOMB Kuala Lumpur

**NEW ZEALAND**
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128 Wakefield Street
P.O. Box 1994
Wellington, C. 1
Tel. 70-769
Cable DENTAL Wellington

**PAKISTAN**
Dodhys Agencies
2, McLeod Road
Lahore 6, West Pakistan
Tel. 66180
Cable DODHYS Lahore

Branch Office:
Dodhys Agencies
9-H, Motijheel
Dacca 2, East Pakistan
Cable DODHYS Dacca

**SINGAPORE**
Mechanical & Combustion
Engineering Company, Ltd.
Alexandra P.O. Box No. 46
9, Jalan Kilang
Singapore 3
Tel. 642361-3
Cable MECOMB Singapore

**SOUTH AFRICA**
Nucleonic Engineering (Pty.), Ltd.
510 Transvalia Buildings
21 Stiemens Street
P.O. Box 1257, Braamfontein
Johannesburg
Tel. 724-9341
Cable NUCLEAR Johannesburg

Branch Office:
Nucleonic Engineering (Pty.), Ltd.
P.O. Box 3641
510 Libertas, Hertzog Boulevard
Foreshore, Cape Town
Tel. 2-7733
Cable NUCLEAR Cape Town

**SYRIA**
Sawah & Co.
Place Azmé
B. P. 2308
Damascus
Tel. 16367, 19697, 14268
Cable SAWAH Damascus

**TAIWAN**
Hwa Sheng Electronic Co., Ltd.
P.O. Box 1558
21 Nanking West Road
Taipei
Tel. 46076, 45936
Cable VICTRONIX Taipei

**TANZANIA**
International Aeradio
(East Africa), Ltd.
P.O. Box 861
Dar-es-salaam

**THAILAND**
Chalermmas
39 Prapithuck Road
Bangkok
Tel. 27508
Cable CHALERMMAS Bangkok

**UGANDA**
International Aeradio (East Africa) Ltd.
P.O. Box 2577
Kampala
Cable INTAERIO Kampala

# INTERNATIONAL SALES and SERVICE OFFICES

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## ELECTRONICS MEASURING EQUIPMENT

### WESTERN EUROPE

**In countries not listed, please contact:**
Hewlett-Packard S.A.
54 Route des Acacias
Geneva, Switzerland
Tel. (022) 42 81 50
Cable HEWPACKSA

**AUSTRIA**
Unilabor H.m.b.H.
Wissenschaftliche Instrumente
Rummelhardtgasse 6/3
P.O. Box 33
Vienna IX/71
Tel. 426 181
Cable LABORINSTRUMENT

**BELGIUM**
Hewlett-Packard Benelux S.A.
20-24 rue de l'Hôpital
Brussels
Tel. 11 22 20
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**DENMARK**
Tage Olsen A/S
Rønnegade 1
Copenhagen Ø
Tel. 29 48 00
Cable TOCOPEN

**FINLAND**
INTO O/Y
Meritullinkatu 11
P.O. Box 153
Helsinki
Tel. 6 11 33
Cable INTO

**FRANCE**
Hewlett-Packard France
150 Boulevard Massena
Paris 13
Tel. 707 97 19
Cable HEWPACK

Branch Office:
Hewlett-Packard France
2 rue Tête d'Or
Lyon, 6 - Rhône
Tel. 52 35 66

**GERMANY**
Hewlett-Packard Vertriebs-GmbH
Kurhessenstrasse 95
Frankfurt a. Main
Tel. 52 00 36
Cable HEWPACKSA

Branch Offices:
Hewlett-Packard Vertriebs-GmbH
Reginfriedstrasse 13
Munich 9
Tel. 49 51 21
Cable HEWPACKSA

Hewlett-Packard Vertriebs-GmbH
Beim Strohhause 26
Hamburg 1
Tel. 24 05 51
Cable HEWPACKSA

Hewlett-Packard Vertriebs-GmbH
(Technisches Büro)
Herrenberger Strasse 110
Böblingen, Württemberg
Tel. 6971
Cable HEPAG

Hewlett-Packard Vertriebs-GmbH
Lietzenburger Strasse 30
1 Berlin W 30
Tel. 24 86 36

Hewlett-Packard Vertriebs-GmbH
Achenbachstrasse 15
4 Düsseldorf 1
Tel. 68 52 58

**GREECE**
K. Karayannis
Klaftmonos Square
Athens 124
Tel. 230 301
Cable RAKAR

**ITALY**
Hewlett-Packard Italiana S.p.A.
Viale Lunigiana 46
Milan
Tel. 69 15 84
Cable HEWPACKIT

Branch Office:
Hewlett-Packard Italiana S.p.A.
Palazzo Italia
Piazza Marconi 25
Rome-Eur
Tel. 591 2544
Cable HEWPACKIT

**NETHERLANDS**
Hewlett-Packard Benelux, N.V.
23 Burg, Roëllstraat
Amsterdam, W.
Tel. (020) 13 28 98
Cable PALOBEN

**NORWAY**
Morgenstierne & Co. A/S
Ingeniørfirma
6 Wessels Gate
Oslo
Tel. 20 16 35
Cable MOROF

**PORTUGAL**
Telectra
Rua Rodrigo da Fonseca 103
P.O. Box 2531
Lisbon 1
Tel. 68 60 72
Cable TELECTRA

**SPAIN**
Ataio Ingenieros
Enrique Larreta 12
Madrid, 16
Tel. 235 43 44-5
Cable TELEATAIO

**SWEDEN**
HP Instrument AB
Centralvägen 28
Solna Centrum
Tel. 08-83 08 30
Cable MEASUREMENTS Stockholm

Branch Office:
HP Instrument AB
Box 4028
Indunagatan 28A
Mölndal 4
Tel. 27 68 00

**SWITZERLAND**
Max Paul Frey
Wankdorffeldstrasse 66
Berne
Tel. (031) 42 00 78

**TURKEY**
Telekom Engineering Bureau
P.O. Box 376 - Galata
Istanbul
Tel. 49 40 40
Cable TELEMATION

**UNITED KINGDOM**
Hewlett-Packard Ltd.
Dallas Road
Bedford, England
Tel. 68052
Cable HEWPIE

**YUGOSLAVIA**
Belram S.A.
83 avenue des Mimosas
Brussels 15, Belgium
Tel. 35 29 58
Cable BELRAMEL

### WESTERN HEMISPHERE

**In countries not listed, please contact:**
Hewlett-Packard Inter-Americas
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Palo Alto, California
Tel. (415) 326-7000
Cable HEWPACK

**ARGENTINA**
Mauricio A. Suárez
Telecommunicaciones
Carlos Calvo 224
Buenos Aires
Tel. (30-6312) (34-9087)
Cable TELEPILOT

**BRAZIL**
Ciental Importacão e Comércio Ltda.
Rua des Eliseu Guilherme, 62
São Paulo 8
Tel. 70-2318
Cable CIENTALCO

**CHILE**
Héctor Calcagni
Casilla 13942
Santiago
Tel. 6.42.26

**CANADA**
Hewlett-Packard (Canada) Ltd.
8270 Mayrand Street
Montreal, Quebec
Tel. (514) 735-2273
Twx 610-421-3484

Branch Offices:
Hewlett-Packard (Canada) Ltd.
1762 Carling Avenue
Ottawa, Ontario
Tel. (613) 722-4223
Twx 610-562-1952

Hewlett-Packard (Canada) Ltd.
1415 Lawrence Avenue West
Toronto, Ontario
Tel. (416) 249-9196
Twx 610-492-2382

Hewlett-Packard (Canada) Ltd.
2184 West Broadway
Vancouver, British Columbia
Tel. (604) 738-7520
Twx 610-922-5050

**PANAMA**
Electronico Balboa, S.A.
P.O. Box 4929
Panama City
Tel. 3-0833
Cable ELECTRON

**PERU**
Fernando Ezeta B
Av. Petit Thouars 4719
Mira Flores
Casilla 3061
Lima
Tel. 5-0346

**PUERTO RICO**
San Juan Electronics, Inc.
Ponce de León No. 150, Stop 3
Pta. de Tierra Sta.
San Juan
Tel. 725-3342
Cable SATRONICS

**VENEZUELA**
Citec, C.A.
Edif. Arisan—Of. No. 4
Avda. Francisco de Miranda
Chacaito
Apartado del Este 10.837
Caracas
Tel. 71.88.05
Cable CITECAL

## OTHER AREAS

**In countries not listed, please contact:**
Hewlett-Packard Company
Export Marketing
1501 Page Mill Road
Palo Alto, California
Tel. (415) 326-7000
Cable HEWPACK

**AUSTRALIA**
Sample Electronics (Vic) Pty., Ltd.
9-11 Cremorne Street
Richmond E.1, Victoria
Tel. 42-4757
Cable SAMPLE Melbourne

Branch Office:
Sample Electronics (N.S.W.) Pty, Ltd.
4 Grose Street
Glebe, New South Wales
Tel. 69-6338
Cable SAMPLE Sydney

**INDIA**
The Scientific Instrument Co., Ld.
6, Tej Bahadur Sapru Road
Allahabad 1
Tel. 2451
Cable SICO Allahabad

Branch Offices:
The Scientific Instrument Co., Ld.
240, Dr. Dadabhai Naoroji Road
Bombay 1
Tel. 26-2642
Cable SICO Bombay

The Scientific Instrument Co., Ld.
11, Esplanade East
Calcutta 1
Tel. 23-4129
Cable SICO Calcutta

The Scientific Instrument Co., Ld.
30, Mount Road
Madras 2
Tel. 86339
Cable SICO Madras

The Scientific Instrument Co., Ld.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel. 271053
Cable SICO New Delhi

**IRAN**
Telecom, Ltd.
P.O. Box 1812
Teheran
Tel. 43850, 48111
Cable BASCOM Teheran

**ISRAEL**
Electronics & Engineering
Division of Motorola Israel Ltd.
16, Kremenetski Street
Tel-Aviv
Tel 35021
Cable BASTEL Tel-Aviv

**JAPAN**
Yokogawa-Hewlett-Packard Ltd.
#59, 1-chome
Yoyogi
Shibuya-ku
Tokyo
Tel. 370-2281
Cable YOKOHEWPACK

Branch Offices:
Yokogawa-Hewlett-Packard Ltd.
#8, Umeda
Kita-ku, Osaka City
Tel. 313-0091

Yokogawa-Hewlett-Packard Ltd.
#59, Kotori-cho
Nakamura-ku
Nagoya City
Tel. 751-8545

**KOREA**
American Trading Co., Korea, Ltd.
Seoul P.O. Box 1103
112-35 Sokong-Dong
Jung-ku, Seoul
Tel. 3.7049, 3.7613
Cable AMTRACO Seoul

**LEBANON**
Constantin E. Macridis
Clemenceau Street
Clemenceau Center
Beirut
Tel. 220846
Cable ELECTRONUCLEAR Beirut

**NEW ZEALAND**
Sample Electronics (N.Z.) Ltd.
8 Matipo Street
Onehunga S. E. 5, Auckland
Tel. 565-361
Cable ELPMAS Auckland

**PAKISTAN**
Mushko & Company, Ltd.
Oosman Chambers
Victoria Road
Karachi 3, West Pakistan
Tel. 54601
Cable COOPERATOR Karachi

Branch Office:
Mushko & Company, Ltd.
Zirat Chambers
31, Jinnah Avenue
Dacca, East Pakistan
Tel. 80058
Cable COOPERATOR Dacca

**SOUTH AFRICA**
F. H. Flanter & Co. (Pty.), Ltd.
Rosella House
Buitencingle Street
Cape Town
Tel. 3-3817
Cable AUTOPHONE Cape Town

Branch Office:
F. H. Flanter & Co. (Pty.), Ltd.
P.O. Box 200, Bramley
775 Pretoria Main Road
Wynberg, Transvaal
Tel. 40-6871

**TAIWAN**
Hwa Sheng Electronic Co., Ltd.
P.O. Box 1558
21 Nanking West Road
Taipei
Tel. 46076, 45936
Cable VICTRONIX Taipei

## OVERSEAS MANUFACTURING PLANTS

**GERMANY**
Hewlett-Packard G.m.b.H.
Herrenberger Strasse 110
Böblingen, Württemberg
Tel. 6971
Cable HEPAG

**ENGLAND**
Hewlett-Packard Ltd.
Dallas Road
Bedford
Tel. 68052
Cable HEWPIE

**JAPAN**
Yokogawa-Hewlett-Packard Ltd.
2270 Ishikawa-cho
Hachioji-shi, Tokyo
Tel. (0426) 3-1231
Cable YOKOHEWPACK Hachioji

# SALES AND SERVICE OFFICES
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TWX: 510-579-2204

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Bellevue, Wash. 98004
11656 N.E. 8th Street
(206) 454-3971
TWX: 910-443-2303

### ARIZONA
Scottsdale, 85251
3009 No. Scottsdale Rd.
(602) 945-7601
TWX: 602-949-0111

Tucson, 85716
232 So. Tucson Blvd.
(602) 623-2564
TWX: 602-792-2759

### CALIFORNIA
North Hollywood, 91604
3939 Lankershim Blvd.
(213) 877-1282 and 766-3811
TWX: 910-499-2170

Sacramento, 95821
2591 Carlsbad Ave.
(916) 482-1463
TWX: 916-444-8683

San Diego, 92106
1055 Shafter Street
(714) 223-8103
TWX: 714-276-4263

Palo Alto, 94303
1101 Embarcadero Rd.
(415) 327-6500
TWX: 910-373-1280

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Englewood, 80110
7965 East Prentice
(303) 771-3455
TWX: 910-935-0705

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Middletown, 06457
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(203) 346-6611
TWX: 710-428-2036

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Miami, 33125
2907 Northwest 7th St.
(305) 635-6461

Orlando, 32803
621 Commonwealth Ave.
(305) 425-5541
TWX: 305-841-2568

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TWX: 813-391-0666

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3110 Maple Drive, N.E.
(404) 233-1141
TWX: 810-751-3283

### HAWAII
North Hollywood, Calif. 91604
3939 Lankershim Blvd.
(213) 877-1282
TWX: 910-499-2170

### ILLINOIS
Skokie, 60076
5500 Howard Street
(312) 677-0400
TWX: 910-223-3613

### INDIANA
Indianapolis, 46205
3919 Meadows Dr.
(317) 546-4891
TWX: 317-635-4300

### LOUISIANA
New Orleans
(504) 522-4359

### MARYLAND
Baltimore, 21207
6660 Security Blvd.
(301) 944-5400
TWX: 710-862-0850

Rockville, 20852
12303 Twinbrook Pkwy.
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Burlington, 01803
Middlesex Turnpike
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24315 Northwestern Hwy.
(313) 353-9100
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(612) 646-7881
TWX: 910-563-3734

### MISSOURI
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TWX: 910-771-2087

St. Louis, 63144
2812 South Brentwood Blvd.
(314) 644-0220
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Englewood, 07631
391 Grand Avenue
(201) 567-3933
TWX: 510-230-9709

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Albuquerque, 87108
6501 Lomas Blvd., N.E.
(505) 255-5586
TWX: 910-989-1655

Las Cruces, 88001
114 S. Water Street
(505) 526-2486
TWX: 910-983-0550

### NEW YORK
New York, 10021
236 East 75th Street
(212) 879-2023
TWX: 710-581-4376

Rochester, 14623
39 Saginaw Drive
(716) 473-9500
TWX: 510-253-5981

Poughkeepsie, 12601
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TWX: 914-452-7425

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(315) 454-2486
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(607) 754-0050
TWX: 510-252-0890

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TWX: 510-926-1516

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Cleveland, 44129
5579 Pearl Road
(216) 884-9209
TWX: 216-888-0715

Dayton, 45409
1250 W. Dorothy Lane
(513) 298-0351
TWX: 513-944-0090

### OKLAHOMA
Oklahoma City
(405) 235-7062

### PENNSYLVANIA
Camp Hill
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West Conshohocken, 19428
144 Elizabeth Street
(215) 248-1600 and 828-6200
TWX: 518-660-8715

Monroeville, 15146
Monroe Complex
Building 2
Suite 2
Moss Side Blvd.
(412) 271-5227
TWX: 710-797-3650

### TEXAS
Dallas, 75209
P.O. Box 7166, 3605 Inwood Rd.
(214) 357-1881
TWX: 910-861-4081

Houston, 77027
P.O. Box 22813, 4242 Richmond Ave.
(713) 667-2407
TWX: 713-571-1353

### UTAH
Salt Lake City, 84115
1482 Major St.
(801) 486-8166
TWX: 801-521-2604

### VIRGINIA
Richmond, 23230
2112 Spencer Road
(703) 282-5451
TWX: 710-956-0157

### WASHINGTON
Bellevue, 98004
11656 N.E. 8th St.
(206) 454-3971
TWX: 910-443-2303

### GOVERNMENT CONTRACTING OFFICE
San Antonio, Texas 78226
Hewlett-Packard
Contract Marketing Division
225 Billy Mitchell Road
(512) 434-4171
TWX: 512-571-0955

### CANADA
Montreal, Quebec
Hewlett-Packard (Canada) Ltd.
8270 Mayrand Street
(514) 735-2273
TWX: 610-421-3484
Telex: 01-2819

Ottawa, Ontario
Hewlett-Packard (Canada) Ltd.
1762 Carling Avenue
(613) 722-4223
TWX: 610-562-1952

Toronto, Ontario
Hewlett-Packard (Canada) Ltd.
1415 Lawrence Avenue West
(416) 249-9196
TWX: 610-492-2382

Vancouver, B.C.
Hewlett-Packard (Canada) Ltd.
2184 W. Broadway
(604) 738-7520
TWX: 610-922-5059

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